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The Armour Engineer

VOLUME XI NOVEMBER, 1919 NUMBER I

THE PORTSMOUTH WATER DEVELOPMENT

Construction Division War Department — Job No. 208

***BY VICTOR M. CROWN, '18**

The Hampton Roads district, comprising Norfolk, Portsmouth, Newport News and vicinity, due to its natural geographic position and proximity to the West Virginia coal fields, became early in the war, one of the major concentration and embarkation points for our overseas forces. At Norfolk were built new army and navy supply bases, costing in the neighboring of $70,000,000, covering an area of ten square miles and containing thirteen immense warehouses. At Portsmouth is located a large navy-yard containing naval supplies and repair facilities capable of accommodating a large portion of our navy, in addition to having one of the largest dry docks in the world.

As a consequence of these and other government activities, too numerous to mention, the existing facilities were strained to the utmost. In particular, the possibility of a shortage in the water supply became so acute about the first of July, 1918, that after a hasty survey of the situation, $1,800,000 was appropriated by the War Department to augment the then existing water supply. The City of Norfolk and environs derive their supply from several lakes in the vicinity, the largest of which is Lake Smith, while Portsmouth, Berkley, and Suffolk are operated on a separate system controlled by the Portsmouth, Berkley, & Suffolk Water Company, taking their water from Lake Kilby and Lake Cahoon, located near Suffolk, Virginia. (See map.)

By raising the dam at Lake Cahoon thirteen feet, it was estimated that an additional impounding reserve water supply of 1,250,000,000 gallons could be obtained at a comparatively small expense. Other means were considered, but this seemed the practical and easiest of execution. The government therefore

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*With Ulen Contracting Co.

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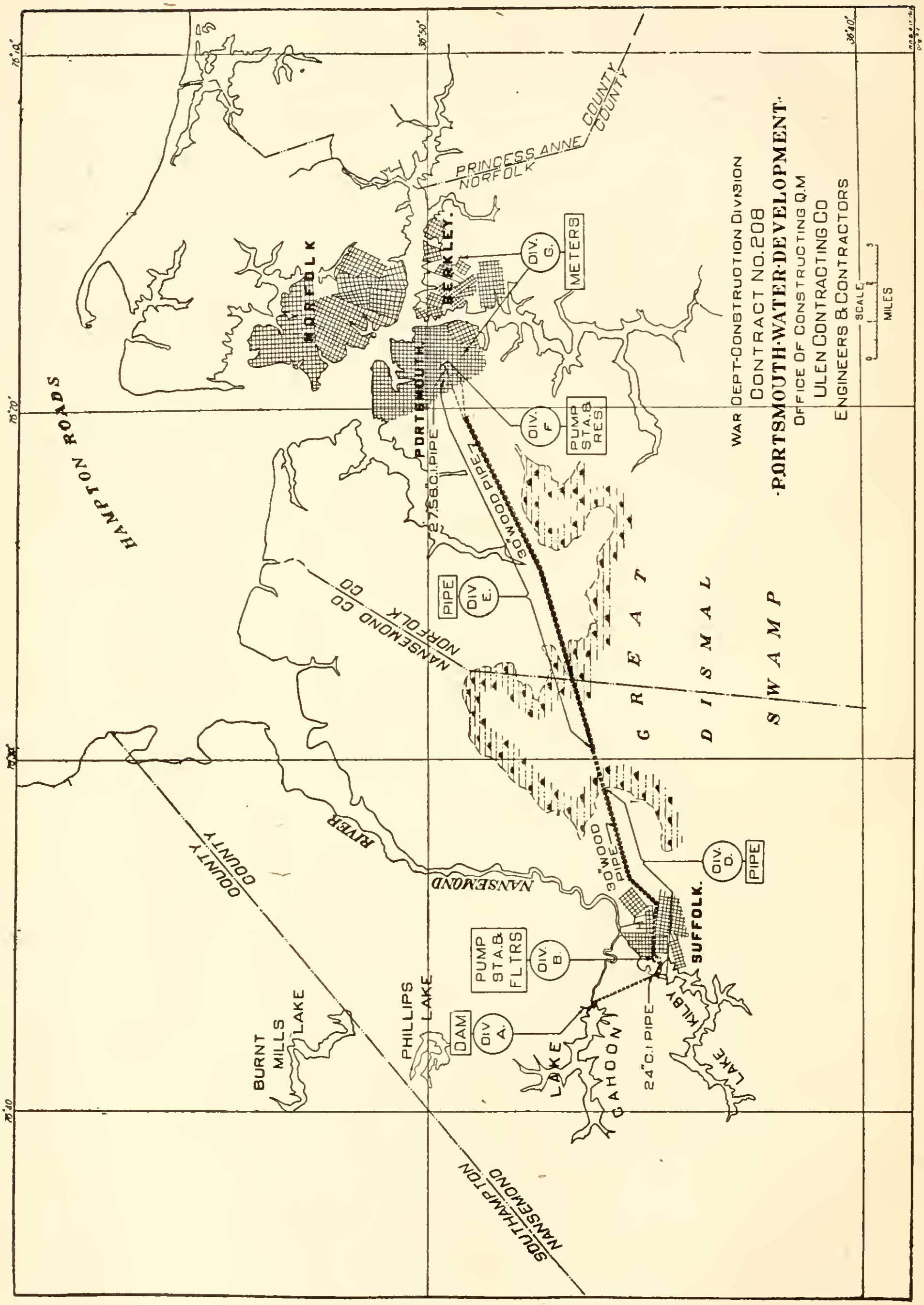

WAR DEPT-CONSTRUCTION DIVISION
CONTRACT NO. 208
·PORTSMOUTH·WATER·DEVELOPMENT·
OFFICE OF CONSTRUCTING Q.M
ULEN CONTRACTING CO
ENGINEERS & CONTRACTORS
SCALE
MILES
HAMPTON ROADS
NORFOLK
BERKLEY.
PORTSMOUTH
SUFFOLK.
PRINCESS ANNE COUNTY
NORFOLK COUNTY
NORFOLK CO
NANSEMOND CO
SOUTHAMPTON COUNTY
NANSEMOND COUNTY
NANSEMOND RIVER
GREAT DISMAL SWAMP
DIV. G. METERS
DIV. F PUMP STA. & RES.
DIV. E. PIPE
DIV. D. PIPE
DIV. B. PUMP STA. & FLTRS
DIV. A. DAM
27.58 C.I. PIPE
30" WOOD PIPE
30" WOOD PIPE
24" C.I. PIPE
LAKE CAHOON
LAKE KILBY
PHILLIPS LAKE
BURNT MILLS LAKE
76°10'
76°20'
76°30'
76°40'
36°50'
36°40'

decided to complete this improvement, and of necessity make other requisite additions, so as to realize on this reserve.

An independent 24-inch line was to be run to the Portsmouth Navy Yard, while the Norfolk and Portsmouth, Berkley and Suffolk systems were to be tied in by a 20-inch subaqueous line across the eastern branch of the Elizabeth River. In this way it would be possible to augment Norfolk's supply by a pumpage of 5,000,000 gallons per day and assist her in supplying the demands of the immense army and navy bases, hospitals and other government projects. Further provision was made for placing a venturi meter at both Norfolk and Berkley ends of the subaqueous 20-inch supply line, so that the demands of Norfolk could be metered or vice versa in case of a breakdown on the Portsmouth, Berkley and Suffolk end. This project is then strictly a government enterprise brought on by war time needs.

The construction work was divided into the Suffolk District, comprising divisions A, B, C and D, and the Portsmouth District including divisions E, F. G and H. The work and scope of these divisions will be described in further details under their respective headings.

Division "A"—Lake Cahoon Dam.

Lake Cahoon has a drainage area of 30.1 square miles, which, when raised from elevation 10.0 to elevation 28.0 will provide a reserve of 1,700,000,000 gallons.

The dam and spillway are located on the southern end of the lake. The spillway presents some unique features of design, inasmuch as it is perhaps the only one of its kind in existence. Instead of the usual type whereby the downstream side is made ogee shaped, it was broken up into a series of cascade (see Fig. 1). This reduces the excessive pressure on the earth foundations by spreading the base. It is 300 ft. long and contains 2,000 cubic yards of concrete with 49.5 tons of reinforçement. A concrete corewall was built containing 600 cubic yards of concrete and 22,500 square feet of rip rap, having side slope of 4.1.

Water is delivered to the Suffolk Pumping Station or direct to Lake Kilby by two Goulds centrifugal pumps—8″ single stage, 3,000,000 gallons per day by 100 ft. head, 1700 R.P.M. 73% efficiency, which are direct connected to a 3-phase, 60 cycle, 2300 volt of 1750 R.P.M. — 75 horsepower squirrel cage induction motor, equipped with starter using a 110-22-2200 volt transformer for operating the no-voltage release.

Due to raising the level of the lake 13 feet, three 14 ft. roadway, wood highway bridges were built. They are 15 ft.—four pile trestle bents—195, 420 and 450 ft. long, containing 2,000 F.B.M. per bent and were made of Southern Cypress at a cost of $12.00 per lineal foot.

Division "B"—Suffolk Pump Station.

Several new additions were made to the Pumping Station, most notable of which are an addition to the settling basin, a re-arrangement of the aerating system, installation of new filter units and force pumps.

The new settling basin is made of reinforced concrete and has a settling capacity of 4,000,000 gallons per 24 hours, based on a six hour period of sedimentation.

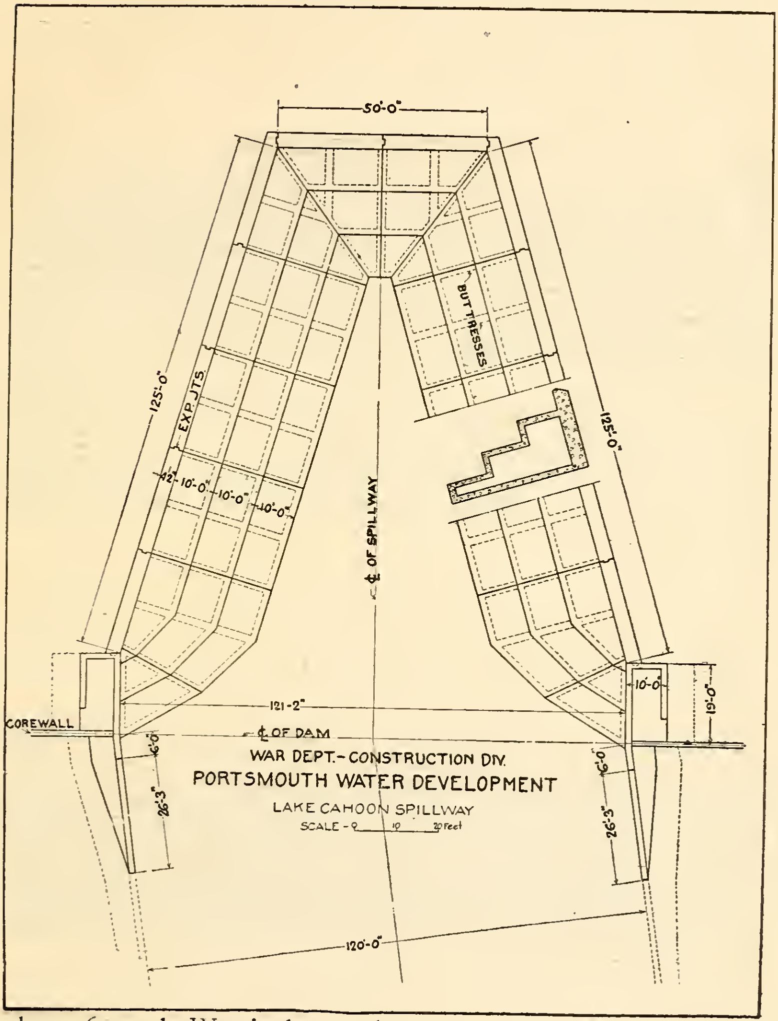
The aerator consists of a weir 170 feet long, over which the water flows, impinging on a series of pipes arranged longitudinally, thereby breaking up the stream into a fine spray. The water then flows thru a mixing chamber having a 15 minute capacity based on a pumpage of 12,00,000 gallons. This is just sufficient to mix the effluent thoroughly and still not break up the coagulent flock.

Eight 500,000 gallon rapid sand filter units were added to the filter house. The mechanical equipment was installed by the Permutit Company of New York. This makes a total of 24 units now in use.

A 12″ single stage Lea-Courtenay centrifugal pump was installed, delivering 4200 G.P.M at 240 ft. head, 1800 R.P.M. and 75% efficiency, which was driven by a 350 H. P. Kerr Turbine running at 4800 R.P.M. and coupled to the pump through a reduction gear. The turbine is equipped with a No. 33 Korting Multi-Jet Condenser, with a 2″ vacuum breaker, and operated by a 6″ double suction centrifugal injection pump, driven by a 15 H.P. Kerr steam turbine.

The Pumping Station was enlarged to accommodate a 355 H.P. Casey-Hedges vertical baffle horizontal water tube boiler, capable of sustaining a working steam pressure of 160 lbs. The boiler plant is supplied by a new 100 H.P. open exhaust, boiler feed water heater and two boiler feed pumps.

To operate the A. C. motor at Lake Cahoon, a 2300 volt, 3-phase, 60 cycle Westinghouse alternator, equipped with 9 K.W., direct connected exciter and driven by a 19x18-250 H. P. Fleming heavy duty Uniflow Engine was installed.



Division "C"—Suffolk Water Meters.

Although originally contemplated, the installation of water meters through the City of Suffolk was postponed to some later date.

Division "D"—Pipe Lines—Suffolk to Swamp.

The pipe installed under this division, from Lake Cahoon to Lake Kilby and the Suffolk Pumping Station were:

1325 feet—20 " cast iron pipe

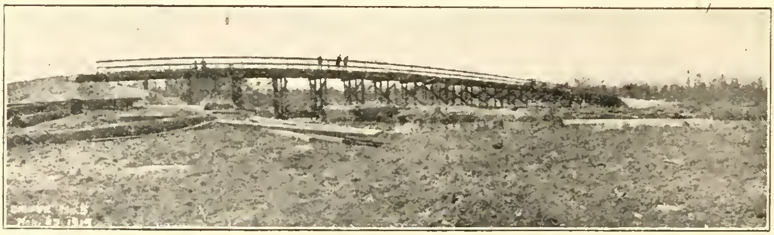
Portsmouth Water Development.
20 & 12" C.I. Supply Lines from Lake Cahoon
North of Virginian Ry. Suffolk Va
Ulen Contracting Co.

675 feet—21.65" cast iron pipe (Argentine)
1250 feet—24 " cast iron pipe
200 feet—30 " cast iron pipe

and from the Suffolk Pumping Station to the west end of Dismal Swamp were:

17,250 feet—30" Redwood wood stave pipe, 250 ft. head
16,750 feet—30" Redwood wood stave pipe, 200 ft. head

The Cahoon pipe lines deliver water from Lake Cahoon thru a 12 and 20 inch cast iron pipe, thence connecting to a 24 inch line (supported on piles thru a swamp) from whence it is connected to the raw water line from Lake Kilby, passing thru a 30 inch cast iron pipe line to the settling basin. Provision was also made for by-passing the Lake Cahoon water direct into Lake Kilby.



Between Suffolk and Portsmouth the pipe passes thru the Great Dismal Swamp, a vast morass extending for over a hundred miles into the State of North Carolina. From Suffolk to the west end of this swamp, there already existed two 20″ cast iron force mains to which were added a 30″ continuous wood stave pipe line laid by the Redwood Manufacturing Company of San Francisco, Calif. By means of a cross connection, these lines are connected to three lines, viz., 16″, 14-16″ and 30″ cast iron pipes, thence going thru the swamp. Near the middle of this swamp, the 16 and 30″ lines are connected to two 20″ lines by means of a 16-20 and 30-20 increaser and reducer respectively. The remaining 16″ line is increased to 20″ and thence to 30″, connecting to a 30″ wood stave pipe which extends to the far east end of the swamp and was laid by the Redwood Manufacturing Company.

30" Redwood Pipe East of Magnolia
Portsmouth Water Development.
Ulen Contracting Co.,
Feb. 7 1919

The cost of 30″ wood stave pipe in the ditch, banded, tested and ready for delivery is but $6.00 per lineal foot, as compared with $20.00 for the same size cast iron pipe. So, thru considerations of economy and also due to the fact that during the war it was almost impossible to obtain cast iron pipe in large quantities, it was deemed advisable to install a 30″ cast iron pipe only through the City of Suffolk and 30″ wood stave pipe as described. In this way, the City of Suffolk could be placed on a separate system, thereby eliminating the large friction loss through the city.

Division "E"—Pipe Lines—Swamp to River.

Between the east end of the swamp and the Portsmouth Pumping Station, there was laid by the Pacific Tank & Pipe Company, of San Francisco, Calif., 18,350 ft. of 150 ft. head 30″ continuous redwood stave pipe and 18,200 ft. of 100 ft. head continuous redwood stave pipe. Connecting to this was 1550 ft. of 27.56″ Argentine cast iron pipe, thru which the filtered water was carried to the Portsmouth Pumping Station and reservoir by means of a 27.56-20″ reducer and a short distance of 20″ pipe, In the City of Portsmouth to the Naval Base was laid 4250 ft. of 24″; 700 ft. of 21.65″ Argentine and 2200 ft. of 16″ cast iron pipe.

Division "F"—Portsmouth Pumping Station.

To provide for the additional water supply, a concrete rectangular reservoir was built having a capacity of 2,000,000 gallons. Provision was also made to aerate the water again thru two 8 ft. diameter perforated steel pans. A new pump unit was added to the equipment being a 400,000 gallon per day Epping-Carpenter Triple Expansion, Duplex Horizontal Steam Driven Pump, equipped with a 225 square foot surface condenser. A 160 H.P. Babcock & Wilcox Stirling Water Tube Boiler, 400 H.P. Feed Water Heater and two Boiler Feed Pumps were added to the boiler room equipment.

Division "G"—Water Meters.

Ten thousand water meters were installed in the cities of Portsmouth and Berkley and were of two types, namely, 5/8″ Trident Disc Neptune and 5/8″ Nash AAX Disc Water Meters.

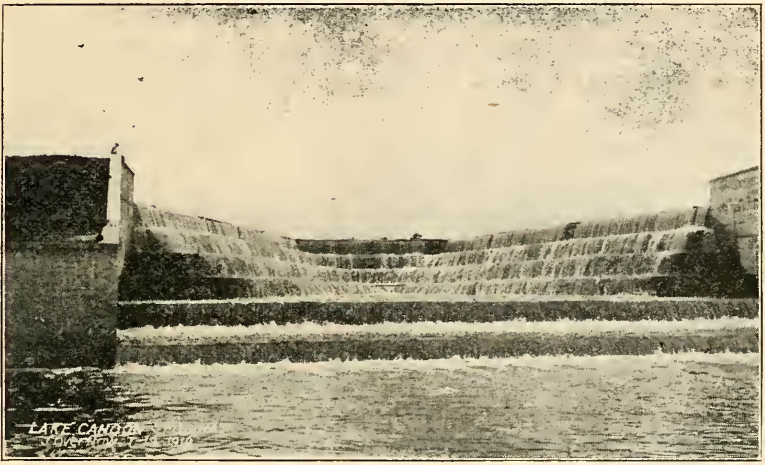
Division "H"—Subaqueous Pipe Lines.

As mentioned previously. the object of this development was to tie in the Portsmouth, Berkley and Suffolk systems with the already overstrained Norfolk water supply system. In order to lay the pipe across the southern and eastern branches of the Elizabeth River, which is about 50 ft. deep at the crossing points, it was decided to use 13 degree joint cast iron pipe and install it by means of an adjustable structural steel pipe laying cradle, supported on a large barge. A 20″ line across the southern branch and a 16″ line across the eastern branch into Norfolk were considered ample.

Summary.

In summing up, at an expenditure of $2,200,000 the impounding water supply of the Portsmouth, Berkley and Suffolk system was raised from one billion to over two billion two hundred and fifty million gallons, the pumpage capacity of the plant increased fifty per cent, amounting to twelve million gallons per day and the capacity of the pipe lines raised to twenty million gallons per day.

Work was begun in October, 1918, and the job was completed in July, 1919, being executed partly at a time when war time conditions prevailed and labor was scarce and of an inferior quality. Great difficulties were experienced in getting deliveries.



While not presenting any great difficulties of an engineering nature, the project was remarkable in one respect, inasmuch as the work extended over a distance of thirty miles, which is considerable, considering the size of the project.

The question of housing was solved by the patriotic spirit of the people of Suffolk, who at the request of the Chamber of Commerce, opened their doors to the foreigners.

The development was completed by the Ulen Contracting Company of Chicago and New York, who were the engineers and contractors, working under the supervision of the Construction Division of the War Department, represented by Captain Benjamin F. Vandevoort, Constructing Quartermaster.

SUBMARINE RADIO-TELEGRAPHY.

BY H. DE FOREST STEVERS, '20.

Before the war submarine radio practically did not exist. That is, when a submarine was running submerged, it could neither receive nor transmit signals by means of its radio system, and thus was isolated from the world and all companion craft, until it came to the surface.

Naturally, when submarines became as active as they did during the conflict, every warring nation felt the need of breaking down this isolation, and set to work upon the problem. Various methods were devised and adopted; but of them all, the one developed by the American investigators bids fair to be the best, in spite of the fact that our workers entered the work much later than any of the others. It is this American method which forms the subject of this paper.

During the year prior to the commencement of American investigation of the problem, the European allied nations had developed a system composed of two receiving coils one meter in diameter with one hundred turns of insulated wire in each. The two coils were mounted at right angles to each other on the deck with the two leads from each passing into the submarine radio room thru watertight insulators. These were used either separately, one to receive fore and aft and the other to receive broadside to the boat, or both in conjunction to receive at intermediate angles. The coils were suitable only for receiving from high-powered radio stations emitting waves of great length, on account of the large "fundamentals," with less efficiency than the system which was developed in this country.*

American investigators felt then that there was a big field for improvement and in the summer of 1917 they set to work. The first phase of their work consisted of finding a suitable insulated antenna which could be operated on or from a submerged submarine for reception of radio signals. Naturally, the simplest antenna, made of a rubber covered wire of a few hundred feet length was tested first by trailing it from a submarine with slight headway to keep the wire out straight astern. Wooden floats at intervals along the wire aided in keeping the antenna in a horizontal position. The wire was completely insulated and at the boat end passed thru a water-tight insulation into the conning tower to the receiving set inside the hull which in turn served as the "ground." A two-stage audion amplifier brought the signals up to the normal reading value.

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* The description of these European multi-turn antenna receiving coils was not available until after the armistice was signed.

The results proved the possibility of receiving messages several feet beneath the surface of sea-water from a high-powered transmittor on a long wave length at several miles distance. This work was done in Key West, Florida, during March, 1917. But the unreliability of a long wire trailed from the stern of a submarine, the danger of getting it cut into pieces by the propellor, and the necessity for headway made this system unsatisfactory. Hence further work became necessary.

The next device took the form of a deck installation that would be permanent and avoid the reeling and unreeling of the antenna. First, the wire as it came from the deck insulator near the conning tower amidships of the boat, was run astern and lashed, then run upward and forward to a radio mast fifteen feet above the deck near the conning tower, then forward and downward and fastened at the bow, where the end was insulated and made waterproof. A submerged receiving test on this form of antenna brought out the following defect:

When a station was "tuned in," and the boat slowly submerged, the signals faded out by becoming detuned, due to the fact that as the water came up over the rubber covered antenna wire, its capacity and hence the tuning was changed, This meant that all of the operator's attention must be concentrated in keeping the signal tuned in, when his time should be free to copy any message coming in.

Many such arrangements were set up on the deck of a submarine and receiving tests made on the long-wave, high-powered U. S. radio transmiting stations. One of the most promising types of these installations consisted of a large single closed turn of insulated antenna wire arranged as follows. Two leads, one from the aerial connection, the other from the ground connection on the receiver, were brought out thru deck insulators near the periscopes, and run to the top of the radio mast, and then one forward to the bow, back along the deck to the stern and thence up to the other to complete the loop. This is now known as the "loop" antenna and compares in efficiency with the same sized ordinary type, and has some further advantages. An explanation of coil antennas has recently been worked out and published.*

In this case, however, the lower half of the loop, running parallel to the deck seemed to have a deadening action on the signals, due no doubt to the proximity to the iron of the deck. This was a weak point in the design. A scheme like this with several turns was compared with the single turn, but contrary to expectations the signal strength showed no increase with any of the added turns.

One day, the happy thought occurred to one of the experimenters to try running the two wires from the set to the top of the mast in the center and then one forward and grounded on the bow of the boat and the other aft and grounded on the stern, thus utilizing the hull of the sub itself for the lower half of the loop. This was indeed a novel idea, for what radio man would have believed that signals could be received with the receiver in the center of a wire, the two ends of which were grounded, the whole thing being immersed in sea water? Yet the results with this discovery not only exceeded expectation, but puzzled the leading radio men of the country for quite a time. None of them could explain why more energy was received than could be accounted for by standard methods of calculation. The utilization of the hull as the lower half of the loop seems to cause this high antenna efficiency. No detuning effect on signals is observed in this case. This type proved to be so far superior to the others that it was adopted "pronto."

The insulated antenna wire employed in these tests consisted of a seven stranded copper cable covered with one-fourth inch of the best insulating rubber. A French type of long-wave receiver, and six stage detector and amplifier was used. Receiving tests could now be made on European radio stations such as Nauen, Germany; Eiffel Tower, Paris, France. Everyone was delighted to find that not only could the signals from these stations be read while on the surface, but also when the submarine was submerged with ten feet of water over the top of the radio mast, the highest point on a boat. These tests were conducted at New London, Connecticut, during the Summer of 1918. Stations such as New Brunswick, New Jersey, could be read with a net submergence of twenty-three feet (wave length 13,000 meters). Results are obtainable at this depth only when the transmitter is of the largest size (110-300 KW), the wave length 6,000 meters or over, and a multi-stage sensitive audion detector-amplifier and long wave receiver is used.

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* Dellinger: Proceedings of A. I. E. E., Oct., 1919, P. 1095.

It became evident in the testing that the strength of the signals being received were maximum when the transmitting station was in the plane of the single turn loop antenna, as off the bow or stern, and practically zero at right angles to the boat, as off the beam.

The manner of making these tests ran as follows: The bow (or stern) of the boat was pointed toward the station to be received, the signals "tuned in" and the boat slowly submerged. The depth in feet could be read from a "depth guage" and the depth at which the signals became too weak to be readable was noted. Many such tests were made on several stations, including boat radio sets of all powers, wave lengths and distances. The results for a 600 meter wave length gave only a net depth of a few inches. In other words, the penetrating depth was found to be proportional to the square of the transmitted wave length. High power only could be utilized in getting results when several feet submerged.

Next the same antenna was tested for transmitting properties. First, a 5 K. W. Poulsen arc was connected to the two lead-in antenna wires in place of the receiving set. Although a current of 20 amperes of high frequency (10,000 meters) could be set up in the loop, no appreciable radiation of energy could be detected at a distance of over a mile. A 1 k. w. spark set at 500 meter wave length and 1-2 amperes antenna current gave a transmitting range 120 miles while on the surface. In submerged tests, however, signals were transmitted only when a portion of the loop protruded above the water. We tried to use longer wave lengths with this combination but ran into the same difficulty as with the arc set, namely, that the radiation fell off rapidly as the wave length was increased. Hence a compromise was made in favor of short wave lengths and partial submergence. This is important nevertheless for a submarine in coming to the surface may send its "recognition signals" to friendly ships in time of war as soon as the radio mast and loop begins to appear and thus avert its being blown to bits. With the old type of bare wire antenna, transmission became possible only after the submarine had been on the surface some time and the aerial insulation had dried off.

In this loop installation a suitable sized condenser was placed in series with the transmitting set and the loop, and, contrary to what would be expected, no tendency developed for the current to puncture the insulation of the wires and short circuit to the surrounding water when submerged. Again in the case of boats at sea, this new type of antenna, on account of its insulation and method of grounding at the ends, functions well when waves and spray are breaking over it, while the old type would be entirely useless.

The transmitting results show the same directional effects as the reception and this fact might be used for secrecy in that the boat could be pointed toward the station to which the message was to be sent. Another great advantage over the old type is that this antenna may be "loaded up" to long wave lengths and "undamped" stations read with an oscillating audion and amplifier from distances several times the former obtainable ranges. Hence with an antenna no larger than formerly used, in all kinds of weather, a submarine captain can copy messages from one continent or another at all points in any transocean voyage. Such a captain now would almost as soon undertake a like voyage without his compass as without his new submarine radio system.

CALCULATION AND MEASUREMENT OF THE FLOW OF FLUID IN PIPES.

BY J. M. NAIMAN, '22.

INTRODUCTION.

(1) Flow Calculation,
(2) Flow Measurement.

The theory underlying the solution of the first problem is dealt with in the following article.

The discussion of the second problem, which, from a practical point of view, is of greater importance, will follow in a later article.

It may be remarked in passing that just as the mechanical engineer is interested in the flow of steam, boiler feed water and air, so is the civil engineer interested in the flow of water in water mains and sewers, and so is the chemical engineer interested in the flow of oil in pipes; while the electrical engineer, besides his somewhat common interests with the mechanical engineer in steam power plants and the civil engineer in hydro-electric power plants, will find some useful applications of electrical instruments to accurate flow measurements, these applications heralding the wide spreading desire of all engineers to obtain accurate mechanical measurements by means of thoroughly reliable electrical instruments, for which an ever increasing field is thus created.

FLOW CALCULATION.

FOREWORD.

Any reader acquainted with the subject of hydraulics and with such simple electrical principles as Ohm's Law, will, no doubt, recollect how often the flow of electricity is explained as being analogous to the flow of a fluid in a pipe. Thus, in the case of a fluid, there are the three correlated factors of (1) *quantity of discharge;* (2) *resistance,* and (3) *drop of pressure;* in the case of electricity, there are the three corresponding factors of (1) *Current,* (2) *resistance,* and (3) *drop of pressure.*

However, while in the case of the electric current, there is a well known accurate relation between the three factors, viz., the relation known as Ohm's Law, no similar relation has yet been found for fluid circuits in pipes. Instead, there are numerous formulas, which differ with the fluids, with the velocities, and even with the sizes of the pipes. In short, there are a number of "Ohm's Laws" for fluids.

It is for the purpose of removing this undesirable feature and establishing one "Ohm's Law" for all fluids, all velocities, and all sizes of pipes, that the author is attempting to solve the problem of the flow of fluids in pipes by the method of general analysis, coupled with suitable experiments.

This paper contains mostly a purely descriptive discussion of the author's hypothesis as to exact nature of the motion of the different particles of the fluid. However, for convenience, the author included a brief explanation of the present state of the theory, as well as discussion of the progress that was made by such past investigators of the subject as Poisseuille, Maxwell, Stokes, Slotte, Meyer, Reynolds, and many others. Also, for the benefit of those who may wish to venture a little deeper into the subject, a brief analysis of the effect of viscosity and related factors was added in small type. It should be remembered, however, that this article is only an introduction to the author's theory. The theory itself, with a discussion of its important applications, will be published later, as soon as the rest of experimental data is secured, tabulated and applied to a further perfection of the theory.

PART I.

The problem is:

Given a horizontal pipe of any size and any material, with any fluid flowing through it; how can we calculate the rate of discharge of the fluid through the pipe, if we know the drop of pressure per foot length of the pipe?

The present method of analysis is as follows:

The average velocity of the flow is maintained constant, since the discharge is uniform. Therefore, the kinetic energy of the fluid stays the same, once the steady flow is established. If there were no friction, this velocity would maintain itself according to Newton's first law of motion. But there is friction, and it must be overcome, or else the velocity will be decreased. It is for this reason that a pressure must be applied to the fluid to keep it in steady motion. This pressure does work against friction. The result is a drop of pressure along the length of the pipe. The energy that is used up to do the work is the potential energy possessed by the fluid because of the fact that it is under pressure. This potential energy is similar to that possessed by a compressed spring. It may be called for convenience pressure potential energy. Of course there may be in addition, some potential energy of position, i. e., such as is due to the fact that the pipe line is more or less inclined, so that everything else being equal, the fluid has more potential energy at the higher than at the lower level. However, most of the potential energy is of the pressure kind, and in case the pipe is a little inclined, our problem is not affected thereby. The only fact that we are interested in is that there is a loss of potential energy, accompanied by a corresponding drop of pressure, and that this energy is used to overcome friction in the pipe.

The question naturally arises as to what relation there is between the drop of pressure and the lost potential energy. We can measure the former, but we must calculate the latter. This relation is a very simple one and is usually stated as follows: The potential energy of a unit volume of a fluid, say one cubic foot, is equal to the pressure which the fluid exerts. Of course, we must remember that by pressure is meant force per unit area, not the *total* force over any given area. The proof of the above statment can be found in any standard text book of physics or mechanics. It is based on the principle of conservation of energy and consists of showing that the work done in forcing 1 cu. foot of additional fluid into a vessel containing the fluid under a pressure, P, is equal to the increase in the potential energy of the fluid. But this work is $P \times \Delta$ volume$=$P, so that the cubic foot of the fluid received P units of potential energy. Since each of the remaining cubic feet is under the same pressure, P, and therefore contains the same amount of potential energy, we have equilibrium as we naturally should.

We see then that a given drop of pressure corresponds to an equal loss of potential energy by each cubic foot of the fluid where the pressure has dropped. This energy is used up in overcoming friction and is converted into heat. In this way the kinetic energy is not affected by friction, and the velocity remains constant. It is the potential energy that bears the burden of overcoming friction. Only when the pressure is reduced to that of the atmosphere or to that of any other medium into which the fluid is discharged, does it become the turn of the kinetic energy to overcome friction, and the velocity is gradually decreased to zero by the friction.

It was found experimentally that the drop of pressure per unit length of the pipe was approximately proportional to the *square* of the velocity of the flow; also to the total *"rubbing"* surface, i. e., the surface of contact between the fluid and the pipe; and finally to the density of the fluid. But the constant of proportionality was found not to be constant at all, changing with the velocity, with the diameter of the pipe, etc. It was consequently called a "cofficient," and attempts were made to find empirically its relation to the velocity, diameter, etc. This resulted in numerous formulas developed by various individuals and differing from each other considerably. They were based upon experimental data, and differed with the nature of the fluid, with the maximum velocity, and even with the diameter of the pipe. For some fluids, especially oils, no empirical formula could be made even approximately true.

All of the above mentioned difficulties were due to the fact that the nature of the friction could not be exactly analyzed. A fluid does not move the same as a solid body, i. e., its particles do not all move together and at the same velocity, but some of them move faster than others. The result is internal friction in addition to the friction due to the surface of the pipe. The relation between the velocity of the fluid and the corresponding internal and surface frictions was the thing sought for. All scientific research concerning this problem seems to have been given up after a famous experiment by Professor Reynolds, of England, as will be shown in Part 2. How the author succeeded in explaining the above phenomenon of friction will be found in Part 3, where the present stage of the theory will be summarized.

PART II.

If we look back into the history of the subject under discussion, we find among its early investigators the famous French scientist Poisseuille. It was the latter who, while studying the flow of water in capillary tubes, discovered the effect of *viscosity,* i. e., of internal friction upon the motion.

From his experiments with the flow of water in capillary tubes, Poisseuille conceived the idea that the volocities at different points of any given cross section of the tube were far from being the same. In fact, he concluded that at the very surface of the tube the fluid was at standstill, and that at the center the velocity was a maximum, the velocity decreasing gradually from the center toward the outside surface of the tube. He also considered that, at points kquidistant from the center, the velocities were the same; consequently the motion of the fluid could be imagined to be that of concentric cylindrical layers similar to the slipping of the tubes of a small packet telescope through one another. This conception brought out the fact that at least in the case of capillary tubes and small velocities, it is nothing but internal friction due to the motion of one cylinderical layer of the fluid over another that uses up energy and causes a drop of pressure down the tube.

The question naturally arises: Just in what way does the internal friction in a capillary tube depend upon the velocity of the fluid and upon the diameter of the tube? To answer this question, Maxwell proposed the following definition for the coefficient of internal friction or viscosity:

Given two horizontal layers of fluid *ab* and *cd* (Fig. 1) *r* cm. apart; in order that a constant relative velocity of *v* cm./sec. may be maintained between the two layers, a constant tangential force per unit area must be applied along the horizontal surface *cd.* It was found experimentally that if the relative velocity, *v,* were *increased,* the tangential force would have to be proportionately *increased.* On the other hand, if the distance, *r,* between the layers were *increased*, the tangential force could be proportionately *decreased.* The exact value of the necessary tangential force, however, depended upon some characteristic of the fluid. It was this factor that determined the constant of

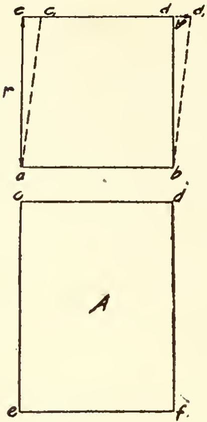

FIG. 1

proportionality in the relation between the tangential force per unit area, F/A, on the one hand, and the relative velocity, v, and distance between layers, r, on the other hand. So that all the previous statements of this paragraph may be summed up by the equation,

$$\frac{F}{A} = \mu \frac{v}{r} \qquad (1)$$

where μ is the constant of proportionality previously mentioned Maxwell called this constant μ, the coefficient of viscosity of the particular fluid under consideration. He found that the coefficient varied with the temperature, increasing with the increase in temperature in the case of gases and decreasing in the case of liquids. He developed a formula for μ, the coefficient of viscosity of gases, in terms of the temperature. Slotte and other scientists developed a simlar expression for various fluids.

Evidently the formula for the *total* tangential force F acting over the total area, A, may be written $F=\mu A \frac{v}{r}$

An inspection of the formula will show that the main factor which determines the tangential force is not so much the relative velocity, v, itself, or the distance between the laryer, r, as the *ratio* between the two or the *rate at which the velocity* *changes with the distance between the layers.* Therefore, we may write the above equation as,

$$F = \mu A \frac{do}{dr} \tag{2}$$

which holds true no matter how the velocity, *v*, varies from point to point.

We have thus found that the force of internal friction, *F*, at any *point* in a tube, depends upon the rate at which the velocity *v*, changes which changes with the distance, *r*, of the point considered from some fixed point of the given cross section, say the center of the tube. We wish to find how the *total* or resultant force of internal friction depends upon the average velocity of the fluid in the tube and upon the diameter of the latter.

Let us consider the fluid contained between layers very close to each other (Fig. 2). There are two viscous forces acting upon the fluid:

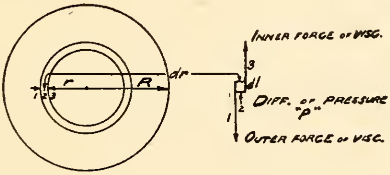

FIG. 2

(1) The outer force of viscosity tends to reduce the velocity of the cylindrical ring to that of the next external ring, which moves slower.

(2) The inner force of viscosity tends to increase the velocity of the ring to that of the next internal ring, which moves faster.

Of the two, the former, i. e., the retarding force, is the stronger, so that a constant difference of pressure is necessary to maintain the constant relative velocity of the ring considered. To satisfy the condition of equilibrium which necessarily exists, there must be a definite relation between the velocity *v*, at any given point and its distance, *r*, from the center of the tube, the relation depending in some way upon the drop of pressure per unit length of the tube. This relation can be shown to be

$$V = \frac{1\ P}{4\mu L} (R^2 - r^2) \tag{3}$$

where P is the drop of pressure over the length L of the tube, and R is the radius of the tube.

It is to be noted that the drop of pressure is proportional to the *first* power of the velocity, not to the *second* power, as is approximately true for large pipes and larger velocities. In the case of capillary tubes and small velocities, however, Poisseuille proved experimentally that the former relation is absolutely true by showing that the total discharge per unit agreed perfectly with the formula,

$$Q = \frac{k\,P\,r^4}{8\,\mu\,L} \qquad (4)$$

where $\frac{P}{L}$ is the drop of pressure per unit length of the tube, R is the radius of the tube, and μ is the coefficient of vicosity of the fluid. This formula is the natural result which can be obtained by integration, when equation (3) for the variable velocity is taken into account.

Consider the two cylindrical layers infinitely close together of radii r and $r+dr$ respectively (Fig. 3). If their axes are taken as dl long, the surface of the first cylinder is $A = 2xrdl$, and that of the second is $A = 2r\ (c \div dr)\ dl$. The tendency of the *lower* force of viscosity to *increase* the velocity of the ring is $F = \mu\, A \frac{dv}{dr}$. The tendency of the upper force of vicosity to *decrease* the velocity of the ring is $F = \mu\, A, \frac{dv}{dr}$. Of the two the latter is the stronger, so that to prevent a retarding effect equal

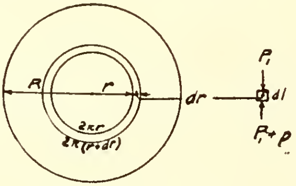

FIG. 3

to F_1-F, a pressure p has to be applied in the direction of the flow, and must be of such a magnitude that $pd = F_1-F$ (3a), a being the area of the cross section of the annular ring.

We wish to express the above condition of equilibrium in terms of the velocity, v, the distance, r, and the drop of pressure per unit length of the tube, $\frac{P}{L}$. Evidently, $F=\mu A\frac{dv}{dr}= \mu 2\pi r dl\frac{dv}{dr}$, and we can find $F1$ by substituting in the last equation $r+dr$ for r. But this is equivalent to adding to F its differential dF with respect to the radius, r; ei. .,

$$F-F=2\pi\mu dl\ d\left\{r\frac{dv}{dr}\right\} \qquad (3b)$$

The counteracting pressure, p, on the other hand, is the result of a difference between the pressure, P_1+p, to the left and the pressure P_1 to the right of the ring. If the drop of pressure per unit length of the tube, $\frac{P}{L}$, is uniform all along the length of the tube, which fact is true for small tubes and small velocities, the drop of pressure for an infinitestimal length, dl, is evidently $\frac{P}{L}dl$, i. e., $P=-\frac{P}{L}dl$ (3c), the negative sign indicating a *drop* instead of an *increase* in pressure. Finally, since the area of the ring is evidently, $a=2\pi rdr$ (3d), we can rewrite the equation (3a),

$\mu=F,-F$, as

$$-\frac{P}{L}dl.\ 2\pi rdr=2\pi\mu dl\ d\left\{r\frac{dv}{dr}\right\}, \text{ or}$$

$$\frac{P}{L}rdr=-\mu\ d\left\{r\frac{dv}{dr}\right\} \qquad (3e).$$

When integrated, equation (3e) becomes

$$\frac{P}{2P}r^2=-\mu\ r\frac{dv}{dr}, \text{ or}$$

$$\frac{P}{2L}rdr=-\mu\ dv \qquad (3f)$$

Another integration gives,

$$\frac{P}{2L}\frac{r^2}{2}=\mu\ v+C \qquad (3g),$$

where C is a constant of integration. Experiment proves that, at the inside surface of the tube, the velocity is zero; we have then the *condition that $v = o$ when $r = R$*, or

$$\frac{PR^2}{4L} = o + c, \text{ or } c = \frac{PR^2}{4L},$$

and equation (3g) becomes,

$$\frac{PR^2}{4L} = -\mu v + \frac{PR^2}{4L}, \text{ or}$$

$$\mu v = \frac{PR^2}{4L} - \frac{Pr^2}{4L} = \frac{P}{4L}(R^2 - r^2), \text{ or}$$

$$v = \frac{1}{4\mu}\frac{P}{L}(R^2 - r^2) \qquad (3),$$

which is the equation sought for.

Evidently, the discharge through the annular ring whose area is $a = \pi r dr$ (Fig. 4; eg. 3d), is

$$dQ = va = \frac{1}{4\mu}\frac{P}{L}(R^2 - r^2)\, 2\pi r\, dr$$

$$= \frac{\pi}{2\mu}\frac{P}{L} r dr (R^2 - r^2) \qquad (4a)$$

Integrating equation *4a* between the limits $r = o$ and $r = R$, we get,

$$Q = -\int \frac{\pi P}{2\mu L}(R^2 r dr - \pi^3 dr) = \frac{\pi P}{2\mu L}[R^2 r^2 - r^4]^{R} - \frac{\pi P R^4}{8\mu L}$$

$$\frac{\pi P}{2\mu L}\left[\frac{R^2 r^2}{2} - \frac{r^4}{4}\right]_{o}^{R} = \frac{\pi P R^4}{8\mu L} \qquad (4),$$

which is the equation Poisseuille found to agree perfectly with his experimental data for capillary tubes and small velocities.

For small tubes and small velocities, the drop of pressure is absolutely proportional to the *first* power of the velocity, not to the *second* power. Also the variation of the velocity from point to point of a given cross section *AB* can be represented by a *parabola*, as shown

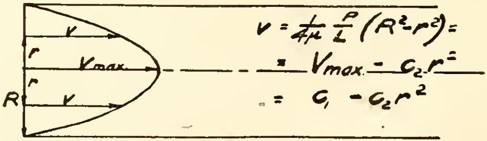

FIG. 4

in Fig. 4. For any given cylindrical ring the average velocity is definite and constant, the fluid contained in the ring traveling in a *straight* line parallel to the axis of the tube.

However, if we increase either the size of the tube or the velocity, or both, we find by experiment that Poisseuille's formula no longer holds, but that the drop of pressure is more closely proportional to the *square* than to the *first* power of the average velocity. To investigate the reason for the variation, as well as the limits within which Poisseuille's formula holds, Professor Reynolds, of England, performed a number of experiments, introducing at the center of the tube some coloring matter, while water was flowing in the tube. For small velocities and small tubes, the coloring matter formed a long, straight colored band continuous to the end of the tube. Also the quantity of discharge agreed perfectly with Poisseuille's law. When, however, the velocity was increased, a certain stage was reached, when the end of the straight band would suddenly bend upward and then downward, then upward again higher than before, the motion finally becoming turbulent, and the whole mass of water following the breaking point becoming colored. Also the flow in the case of the higher velocities did not follow Poisseuille's law any more, the drop of pressure becoming approximately proportional to the *square* of the velocity.

These experiments seemed to discourage any further research concerning the nature of the fluid motion, the reason for the turbulent motion being unknown. Reynolds himself gave up all attempts to solve the problem analytically, but has developed an empirical formula for the flow of water in pipes. However, his empirical formula was an advance in the right direction, as compared with the formulas of his predecessors, such as Darcy and others, inasmuch as it took into account the coefficient of viscosity of the fluid and the temperature of the fluid at the source. The formulas now commonly used are various slight modifications of Darcy's formula, differing from the latter chiefly in the expression for the so-called "coefficient," as pointed out in Part I. They all neglect the factor of the coefficient of viscosity and that of temperature, and are only applicable for a very limited range of velocities and diameters in the case of only one particular fluid, such as water.

But even Reynolds, taking into account the coefficient of viscosity and the initial temperature, neglected to consider the fact that the temperature increases in the direction of motion, affecting the value of the coefficient of viscosity and varying the factors determining the nature of the motion at different points of any given cross section. How important the effect of the variation of the temperature is will be illustrated in Part III., in which the author's theory will be evolved.

PART III.

The source of all friction losses of a fluid flowing in a pipe may be traced to viscosity. If the fluid were non-viscous, i. e., if one layer of the fluid could flow over another without any friction whatsoever, the outer layer of the fluid would adhere to the surface of the pipe, and the rest of the fluid would slide over the outer layer in one mass; in other words, the fluid would behave in the same manner as a solid would, except that there would not even be any "skin friction," since the fluid is supposed to be non-viscuous. In that case, there would be no friction losses, and no pressure would be necessary to maintain the fluid in motion once it was started. However, as soon as we consider the ordinary fluid, which always has the property of viscosity, we can see that, because of the internal friction or viscosity, the outer layer will slow up the next layer, which in turn will slow up the one next to itself, etc., until the stage is reached when the retarding effect upon any cylindrical ring is exactly counter-balanced by the resultant pressure which tends to move the ring forward. We have seen that this equilibrium is not reached until the velocity at different points of any cross section follows the parabolic law,

$$v = \frac{1}{4\mu} \frac{P}{L} (R^2 - r^2) \qquad \text{(See Eq. 3).}$$

Evidently, if the coefficient of viscosity, μ, remained constant, nothing ought to disturb the equilibrium, and we should have a permanent self-existing state. This must be so, since the drop of pressure per length of the pipe, $\frac{P}{L}$, will remain constant as long as the previous conditions do not change. The law of the velocity will then remain fixed as expressed by the equation given above. The question naturally arises: does μ stay constant?

We have seen that the coefficient of viscosity, μ, changes with the temperature. Further, we know that the pressure potential energy lost because of friction is changed into heat. The part lost by transfer to the outside evidently raises the temperature of the fluid and thereby usually decreases the coefficient of viscosity (it always increases it in the case of gases). Naturally it is important to know just to what extent the coefficient of viscosity, μ, is changed at different points of any given cross section.

Suppose that the tube as well as the velocity is small. Then the drop of pressure for an infinitessimal length of the tube, i. e., $\frac{P}{L}\,dl$, corresponds to an equal loss of pressure potential energy, $\frac{P}{L}\,dl$, by each cubic foot of the volume, $2\pi r\, dr\, dl$ of any cylindrical annular ring (Fig. 5). The total loss of energy increases with the volume, since it is proportional to the latter, but the loss of energy for *each cubic foot* is always equal to the drop of pressure, independently of the position, r, of the cylinder; as a result, the gain of heat by each cubic foot of the fluid is also the same at any point. Consequently, if none of the heat were lost, each cubic foot of the fluid would gain the same increase in temperature, and the latter would remain uniform as before. This would also be true if the loss of heat instead of being *zero* were of the *same* value for different points of any given cross section. If the tube is small, the radiation of heat practically satisfies the above condition, especially if the velocity is small enough to give ample time for radiation. Therefore, for small tubes and small velocities, the temperature remains practically uniform at all points of any given cross section and increases but slightly for any ordinary length of the tube; the result is that if the coefficient of viscosity, μ is figured at a temperature which is the mean of the temperatures at the beginning and at the end of the tube, μ is still a constant, and

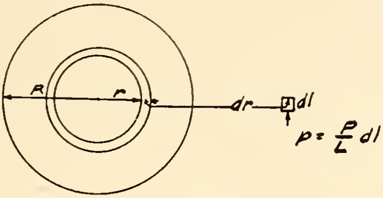

FIG. 5

the relation,

$$v = \frac{1}{4\mu} \frac{P}{L} (R^2 - r^2) \qquad \text{(See Eq. 3)},$$

still holds.

But as the rate at which heat is produced increases, the rate at which heat is lost increases very rapidly, and a stage is reached when more heat is lost at points closer to the surface of the tube or pipe than at those closer to the center of the tube or pipe. The gradient of temperature difference will be the more the larger the diameter of the pipe, especially since the fluids usually flowing in pipes are poor conductors. It will also increase with the velocity. This variation of temperature from point to point of any given cross section plays a very important part in the new law which the velocity, v, must follow. Evidently this law, in the case of larger pipes and larger velocities, is not the same as in the case formerly considered, since the nature of the motion cannot be that of concentric cylindrical layers any more.

To show this, let us consider the several effects of the variation of temperature from point to point of any cross section of the pipe:

First, the coefficient of viscosity will differ from point to point; as a result, at the point where the viscosity will be smaller there will be a smaller drop of pressure per unit length of the line through the point; viz., since

$$v = \frac{1}{4\mu}\frac{P}{L}(R^2—1^2), \mu = \frac{1}{4v}\frac{P}{L})A^2 r^2) = K\frac{P}{L},$$

or the drop of pressure per unit length of the pipe, i. e., $\frac{P}{L}$, is proportional to the coefficient of viscosity, μ. Immediately, the important condition—that the pressure at different points of any cross section is the same—no longer holds, and the result will be upward and downward motion or eddy currents in addition to the regular forward motion. Besides this cause of eddy currents, there is another one: that due to the variation of the density, which is a function of the temperature. The latter eddy currents are similar in nature to those produced when water or any other liquid in a kettle is heated from the bottom, i. e., these currents are nothing but convection currents.

It is easy to see from the foregoing facts that the resultant of the streamline and eddy currents will be a turbulent motion of exactly the same nature as the one discovered by Professor Reynolds in his famous historical experiment previously mentioned. We may compare our theoretical turbulent motion with Reynold's photographs of the coloring matter which he used in his experiments with water.

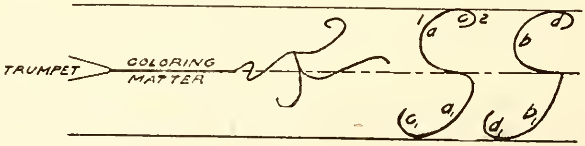

FIG. 6

Fig. 6 is a rough reproduction of one of these photographs. The coloring matter introduced at the trumpet first traveled in a straight horizontal line, and upon reaching a point at a fixed distance from the trumpet began to move in a sinuous wave, gradually branching out and finally assuming a constant motion, represented by the last two lines. The lack of symmetry between the motions in the upper and lower halves of the pipe is the most striking point that draws our attention. Yet, when we consider that the tendency of the variable pressures and temperatures to reach equilibrium must produce different results in the two halves of the pipe, the lack of symmetry is not surprising. For, in the upper half of the pipe, the increase of the temperature from the center of the pipe outward causes a drop of pressure from the center of the pipe and eddy currents in the same direction; in addition, it also causes convection currents. These currents in moving outward, i. e., away from the center of the pipe, are opposed by the force of viscosity and by the force of gravity, the latter opposition being maximum for the upward motion and minimum and zero for the horizontal motion to the right and left of the horizontal axis of the pipe. On the other hand, in the lower half of the pipe, the downward eddy currents due to the drop of pressure are aided by gravity, and there are not any convection currents, since the higher temperatures are already on correspondingly higher levels.

As a result, in the upper half the particles urged by a higher pressure move slightly upward; and since at the higher level the pressure may be smaller, not only in the same cross section, but even a little behind the cross section considered, the particles move backward as well as upward, until the internal friction losses bring the pressure of the moving particles down to that of the particles at the same level. Then the pressure and temperature effects combine to move the particles upward against the force of gravity and that of internal friction, the pressure gradually decreasing until, at some level close to the upper surface of the pipe, the pressure of the surrounding particles is higher than that of the moving particles. This causes the motion to become forward as well as upward until the current strikes the upper half of the pipe at some acute angle. (See Fig. 6, *a and b.*)

On the other hand, in the lower half the pressure decreases downward; as a result, the fluid particles at first move downward. Since in this case gravity aids the motion, the drop of pressure is now much less than in the case previously considered, and as the lower portions of the pipe are reached, the pressure of the surrounding particles is less than the remaining pressure of the moving particles; therefore, the motion becomes backward as well as downward, until the current strikes the lower half of the pipe at some obtuse angle (See Fig. 6, *a*, *b*.)

Again, we notice that the eddy currents in their outward motion must change their direction upon striking the inside surface of the pipe. The motion after the rebounding will necessarily be much slower, since the larger part of the energy of the eddy current fluid particles will be changed into heat. In the upper half of the pipe, because of the reduced velocity and the lower density of the striking fluid particles as compared to that of the original particles at the surface, the tendency to move downward will be quickly reduced to zero, and the motion will become horizontal; but the pressure of the surrounding particles drops from point 1 to point 2 (Fig. 6); thereby the pressure of the intruding particles will be comparatively higher and will cause the latter to move backward, until internal friction will reduce the pressure to that of the surrounding particles. Then the intruding particles will become of the same characteristics as those of the neighboring fluid and will have the same motion as the latter. In the lower half of the pipe, however, the particles upon striking the bottom of the pipe will rebound, moving backward and upward, until work done against gravity and internal friction, as well as energy lost as heat upon impact, will reduce the velocity and the pressure of the intruding particles to that of the neighboring fluid, and the motion of the particles will become the same as that of the surrounding fluid. An inspection of the last two curved lines in Fig. 5 shows how well experimental facts agree with what *may* occur according to our purely theoretical considerations.

Another important point is this one: We have seen that heat energy is produced when the eddy currents strike and rebound from the inside surface of the pipe and thereby cause a loss of pressure potential energy and a corresponding drop of pressure. Evidently the heat produced to the impact is similar in its nature to that produced when two solid bodies of medium elasticity collide. The heat produced, when one of the bodies is a sphere, and the other body is some immovable obstacle, such as a wall, is usually expressed as,

$$H = (1-e^2)\frac{mv^2}{2} \qquad (5),$$

where H is lost heat energy, in ergs, e is the co efficient of restitution of the colloding bodies, m is the mass of the sphere, and v is its velocity before impact. Something similar must happen in the case of fluid impact, e, the coefficient of restitution in this case, depending upon the nature of the fluid and upon the material of the pipe. The heat lost because of the impact of a fluid against a pipe must bear some relation to the velocity of impact similar to that expressed in Ex. 5. Since the coefficient of restitution of such inelastic bodies as liquids must be some small fraction, the heat lost because of the impact and the corresponding drop of pressure must be very appreciable and in fact may overshadow other friction losses. We can see from the foregoing how the factor of the *square* of the velocity and that of the roughness of the pipe (expressed by e) enter into our theory in perfect accord with the experimental facts upon which the current empirical formulas are based.

We see then that the turbulent motion of fluid in a pipe is the resultant of several simpler motions: 1, the horizontal motion maintained by the drop of pressure down the line against the force of viscosity; 2, the convection currents caused by unequal distribution of temperature, and consequently of density, usually opposed by the force of gravity and by that of viscosity; 3, the eddy currents caused by disturbed pressure equiplibrium at different points of any given cross section, opposed by the force of viscosity and opposed or aided, as the case may be, by the force of gravity; and, 4, the rebounding motion after collision with the pipe, opposed by the force of viscosity and opposed or aided by the force of gravity. Our general problem thus resolves itself into the four simper ones just enumerated. The first one has already been solved in the past by Poisseuille, Maxwell, and others, as previously explained. The last three, however, have never been attacked, except that Fourier has done some work in convection currents. The chief reason why these problems have not been solved so far is that they never suggested themselves from the same light as they appear here, so that their importance escaped notice. They are all possible of solution, however, and as soon as all the necessary experiments are completed, the solutions will be published, and the derivation of a general "Ohm's Law" for the flow of any fluid in a pipe will be included in the analytical development of the new theory. In addition, the numerous practical applications of the new theory will be thoroughly discussed.

COLLISION OF α-PARTICLES WITH LIGHT ATOMS

BY SIR E. RUTHERFORD, F. R. S.

From a discourse delivered at the Royal Institution on June 6 and published in "Nature" July, 1919.

The discovery of radio-activity has not only thrown a flood of light on the processes of transformation of radio-active atoms; it has at the same time provided us with the most powerful natural agencies for probing the inner structure of the atoms of all the elements. The swift α-particles and the high-speed electrons or β-rays ejected from radio-active bodies are by far the most concentrated sources of energy known to science. The enormous energy of the flying α-particle or helium atom is illustrated by the bright flash of light it produces when it impacts on a crystal of zinc sulphide, and by the dense distribution of ions along its trail through a gas. This great store of energy is due to the rapidity of its motion, which in the case of the α-particle from radium C (range 7 cm. in air) amounts to 19,000 km. per second, or about 20,000 times the speed of a rifle-bullet. It is easily calculated that the energy of motion of an ounce of helium moving with the speed of the α-particle from radium C is equivalent to 10,000 tons of solid shot projected with a velocity of 1 km. per second.

In consequence of its great energy of motion the charged particle is able to penetrate deeply into the structure of all atoms before it is deflected or turned back, and from a study of the deflection of the path of the α-particle we are able to obtain important evidence on the strength and distribution of the electric fields near the centre or nucleus of the atom.

Since it is believed that the atom of matter is, in general, complex, consisting of positively and negatively charged parts, it is to be anticipated that a narrow pencil of α-particles, after passing through a thin plate of matter, should be scattered into a comparatively broad beam. Geiger and Marsden showed not only that much small scattering occurred, but also that in passing through the atoms of a heavy element some of the α-particles were actually turned back in their path. Considering the great energy of motion of the α-particle, this is an arresting fact, showing that the α-particle must encounter very intense forces in penetrating the structure of the atom. In order to explain such results, the idea of the nucleus atom was developed in which the main mass of the atom is concentrated in a positively charged nucleus of very small dimensions compared with the space occupied by the electrons which surround it. The scattering of α-particles through large angles was shown to be the result of a single collision where the α-particles passed close to this charged nucleus. From a study of the distribution of the particles scattered at different angles, results of first importance emerged It was found that the results could be explained only if the electrical forces between the α-particle and charged nucleus followed the law of inverse squares for distances apart of the order of 10^{-11} cm. Dadwin pointed out that the variation of scattering with velocity was explicable only on the same law. This is an important step, for it affords an expermental proof that, at any rate to a first approximation, the ordinary law of force holds for electrified bodies at such exceedingly minute distances. It was also found that a resultant charge on the nucleus measured in fundamental units was about equal to the atomic number of the element. In the case of gold this number is believed from the work of Moseley to be 79.

Knowing the mass of the impinging α-particle and of the atom with which it collides, we can determine from direct mechanical principles the distribution of velocities after the collision, assuming that there is no loss of energy due to radiation or other causes. It is important to notice that in such a calculation we make no assumption as to the nature of the atoms or of the forces involved in the approach and separation of the atoms. For example, if an α-particle collides with another helium atom, we should expect the α-particle to give its energy to the helium atom, which could thus travel on with the speed of the α-particle. If an α-particle collides directly with a heavy atom, *e. g.*, of gold of atomic weight 197, the α-particle should retrace its path with only slightly diminished velocity, while the gold atom moves onward in the original direction of the α-particle, but with about one-fiftieth of its velocity. Next, consider the important case where the α-particle of mass 4 makes a direct collision with a hydrogen atom of mass 1. From the laws of impact, the hydrogen atom is shot forward with a velocity 1.6 times that of the impinging α-particle, while the α-particle moves forward in the same direction, but with only 0.6 of its initial speed. Marsden showed that swift hydrogen atoms set in motion by impact with α-particles can be detected like α-particles by the scintillations produced in a zinc sulphide crystal. Recently I have been able to measure the speed of such H atoms and found it to be in good accord with the calculated value, so that we may conclude that the ordinary laws of impact may be applied with confidence in such cases. The relative velocities of the α-particles and recoil atom after collision can thus be simply illustrated by impact of two perfectly elastic balls of masses proportional to the masses of the atoms.

While the velocities of the recoil atoms can be easily calculated, the distance which they travel before being brought to rest depends on both the mass and the charge carried by the recoil atom. Experiment shows that the range of H atoms like the range of α-particles, varies nearly as the cube of their initial velocity. If the H atom carries a single charge, Darwin showed that its range should be about four times the range of the α-particle. This has been confirmed by experiment. Generally, it can be shown that the range of a charged atom carrying a single charge is mu^3R, where m is the atomic weight, and u the ratio of the velocity of the recoil atom to that of the α-particle and R the range of the α-particle before the collision. In comparison of theory with experiment, the results agree better if the index is taken as 2.9 instead of 3. If, however, the recoil atom carries a double charge after a collision, it is to be expected that its range would only be about one-quarter of the corresponding range if it carried a single charge. It follows that we cannot expect to detect the presence of any recoil atom carrying two charges beyond the range of the α-particle, but we can calculate that any recoil atom, not greater than oxygen and carrying a single charge should be detected beyond the range of the α-particle. For example, for a single charge the recoil atoms of hydrogen and helium should travel 4 R, lithium, 2.8 R, carbon 1.6 R, nitrogen 1.3 R, and oxygen 1.1 R, where R is the range of the incident α-particles. We thus see that it should be possible to detect the presence of such singly charged atoms, if they exist, after completely stopping the α-particles by a suitable thickness of absorbing material. This is a great advantage, for the number of such swift recoil atoms is minute in comparison with the number of α-particles, and we could not hope to detect them in the presence of the much more numerous α-particles.

In order to calculate the number of recoil atoms scattered through any given angle from the direction of flight of the α-particles, it is necessary, in addition, to make assumptions as to the constitution of the atoms and as to the nature and magnitude of the forces involved in the collision. Consider, for example, the case of a collision of an α-particle with an atom of gold of nuclear charge 79. Assuming that the nucleus of the α-particle and that of the gold atom behave like point charges, repelling according to the inverse square law, it can readily be calculated that, for direct collision, the α-particle from radium C, which is turned through an angle of 180°, aproaches within a distance $D = 3.6 \times 10^{-12}$ cm. of the centre of the gold nucleus. This is the closest possible distance of approach of the α-particle, and the distance increases for oblique collisions. For example, when the α-particle is distributed through an angle of 150°, 90°, 30°, 10°, 5°, the closest distances of aproach are 1.01, 1.2, 2.4, 6.2, 12 D respectively.

In the experiments of Geiger and Marsden, the number of α-particles scattered through 5° was observed to be about 200,000 times greater than the number through 150°. The variation with angle was in close accord with the theory, showing that the law of inverse squares holds for distances between 3.6×10^{-12} cm. and 4.3×10^{-12} cm. in the case of the gold atom. The experiments of Crowther in 1910 on the variation of scattering of β-rays with velocity indicate that similar law holds also in that case, and for even greater distances from the nucleus.

We have seen that Marsden was able by the scintillation method to detect hydrogen atoms set in swift motion by α-particles up to distances about four times the range of the incident α-particle. In Marsden's experiments a thin-walled glass tube filled with radium emanation served as an intense source of rays. Since the lack or homogenity of the α-radiation and the absorption in the glass are great drawbacks in making an accurate study of the laws controlling the production of swift atoms by impact, I have found it best to use for the purpose a homogeneous source of radium C by exposing a disc in a strong source of emanation. Fifteen minutes after removal from emanation the α-rays from the disc are practically homogeneous, with a range in air of 7cm. By special arrangements very intense sources of α-radiation can be produced in this way, and in the various experiments discs have been used the v-ray activity of which has varied between 5 to 80 milligrams or radium. Allowance can easily be made for the decay of the radiation with time

In the experiments with hydrogen the source was placed in a metal box about 3 cm. away from an opening in the end covered by a thin sheet of metal sufficient to absorb the α-rays completely. A zinc sulphide screen was mounted outside about 1 mm. away from the opening, so as to allow for the insertion of absorbing screens of aluminum or mica. The apparatus was filled with dry hydrogen at atmospheric pressure. The H atoms striking the zinc sulphide screen were counted by means of a miscroscope in the usual way. The strong luminosity due to the β-rays from radium C was largely reduced by placing the apparatus in a powerful magnetic field which bent them away from the screen.

If we suppose, for the distances involved in a collision, that the α-particle and hydrogen nucleus may be regarded as point charges, it is easy to see that oblique impacts should occur much oftener than head-on collisions, and consequently that the stream of H atoms set in motion by collisions should contain atoms the velocities of which vary from zero to the maximum produced in a direct collision. The slow velocity atoms should greatly preponderate, and the number of scintillations observed should fall off rapidly when absorbing screens are placed in the path of the rays close to the zinc sulphide screen.

A surprising effect was, however, observed. Using α-rays of range 7cm., the number of H atoms remained unchanged when the absorption in their path was increased from 9 cm. to 19 cm. of air equivalent. After 19 cm. the number fell off steadily, and no scintillations could be observed beyond 28 cm. air absorption. In fact, the stream of H atoms resembled closely a homogeneous beam of α-rays of range 28 cm., for it is well known that, owing to scattering, the number of α-particles from a homogeneous source begin to fall off some distance from the end of their range. The results showed that the H atoms are projected forward mainly in the direction of the α-particles and over a narrow range of velocity, and that few, if any, lower velocity atoms are present in the stream.

If we reduce the velocity of the α-particle by placing a metal screen over the scource, it is found that the distribution of H atoms with velocity changes, and that the rays are no longer nearly homogeneous. When the range of the α-rays is reduced to 3.5 cm., the absorption of the H atoms is in close accord with the value to be expected from the theory of point charges. It is clear, therefore, that the distribution of velocity among the H atoms varies markedly with the speed of the incident α-particles, and this indicates that a marked change takes place in the distribution and magintude of forces involved in the collision when the nuclei approach closer than a certain distance.

In addition to these peculiarities, the number of H atoms is greatly in excess of the number to be expected on the simple theory. For example, for the swiftest α-rays the number which is able to travel a distance equipvalent to 19 cm. of air is more than thirty times greater than the calculated value. The variation in number of H atoms with velocity of the incident α-particle is also entirely different from that to be expected on the theory of point charges. The number diminishes rapidly with velocity and is very small for α-particles of range 2.5 cm.

It must be borne in mind that the production of a high-speed H atom by an α-particle is an exceedingly rare occurrence. Under the conditions of the experiment the number of H atoms is seldom more than 1/30,000 of the number of α-particles. Probably each α-particle passes through the structure of 10,000 hydrogen molcules in traversing one centmeter of hydrogen at atmospheric pressure, and only one α-particle in 100,000 of these produces a high-speed H atom; so that in 10^9 collisions with the molecules of hydrogen the α-particle, on the average, approaches only once close enough to the centre of the nucleus to give rise to a swift hydrogen atom.

We should anticipate that for such collisions the α-particle is unable to distinguish between the hydrogen atom and the hydrogen molecule, and that H atoms should be liberated from matter containing free or combined hydrogen. This is fully borne out by experiment.

From the number of H atoms observed it can be easily calculated that the α-particle must be fired within a perpendicular distance of 2.4×10^{-13} cm. of the centre of the H nucleus in order to set it in swift motion. This is a distance less than the diameter of the electron, viz., 3.6×10^{-13} cm. The general results obtained with α-rays of range 7 cm. are similar to those to be expected if the α-particle behaves like a charged disc, of radius about the diameter of an electron, travelling with its plane perpendicular to the direction of motion.

It is clear from the experiments with hydrogen that, for distances of the order of the diameter of the electron the α-particle no longer behaves like a point charge, but that the α-particles must have dimensions of the order of that of the electron. The closest distance of approach in these collisions in hydrogen is about one-tenth the corresponding distances in the case of a collission of an α-particle with an atom of gold.

The results obtained with hydrogen in no way invalidate the nucleus theory as used to explain the scattering of α-rays by heavy atoms, but show, as we should expect, that the theory breaks down when we approach very close to the nucleus structure. In our ignorance of the constitution of the nucleus of the α-particle we can only speculate as to its structure and the distribution of forces very close to it. If we take the α-particle of mass 4 to consist of four positively charged H nuclei and two negative electrons, we should expect it to have dimensions of the order of the diameter of the electron, supposing, as seems probable, that the H nucleus is of much smaller dimensions than the electron itself. When we consider the enormous magnitude of the forces between the α-particles and the H nucleus in a close collision—amounting to 6 kg. of weight—it is to be expected that the structure of the α-particle should be much deformed, and that the law of force may undergo very marked changes in direction and magnitude for small changes in the closeness of approach of the two colliding nuclei. Such considerations offer a reasonable explanation of the anomalies shown in the number and distribution with velocity of the H atoms exhibited for different velocities of the α-particles.

When we consider the enormous forces between the nuclei, it is not so much a matter of surprise that the nuclei should be deformed as that the structure of the α-particle or helium nucleus escapes disruption into its constituent parts. Such an effect has been carefully looked for, but so far no definite evidence of such a disintegration has been observed. If this is the case, the helium nucleus must be a very stable structure to stand the strain of the gigantic forces involved in a close collision.

We have seen that the recoil atoms of all elements of atomic mass less than 18 should travel beyond the range of the α-particle, provided they carry a single charge. Preliminary experiments, in which the α-particle passes through pure helium, showed that no long-range recoil atoms were present, indicating that after recoil the helium atom carries a double charge. In a similar way no certain evidence has been obtained of long-range recoil atoms from lithium, boron or beryllium. It is difficult in experiments with solids or solid compounds to be sure of the absence of hydrogen or water-vapour, which results in the production of numerous swift H atoms. These difficulties are not present in the case of nitrogen and oxygen, and a special examination has been made of recoil atoms in these gases. Bright scintillations were observed in both these gases about 2 cm. beyond the range of the α-particle. These scintillations are, presumably, due to swift N and O atoms carrying a single charge, for the ranges observed are about those to be expected for such atoms. The scintillations due to recoil atoms of N and O are much brighter than H scintillations, although the actual energy of the flying atom is greater in the latter case. This difference in brightness is probably connected with the much weaker ionisation per unit of path due to the swifter H atom.

The corresponding range of the recoil atoms was about the same in oxygen, nitrogen, and carbon dioxide. Theoretically, it is to be expected that the N recoil atom should give a somewhat greater range than the O atom. The recoil atoms observed in carbon dioxide are aparently due to oxygen, for if the carbon atoms carried a single charge they should be detected beyond the range of O atoms.

The number of recoil atoms in nitrogen and oxygen and their absorption indicate that these atoms, like H atoms, are shot forward mainly in the direction of the αparticles. It is clear from the results that the nuclei of the atoms under consideration cannot be regarded as point charges for distances of the order of the diameter of the electron. Taking into account the close similarity of the effects produced in hydrogen and oxygen, and the greater repulsive forces between the nuclei in the latter case, it seems probable that the abnormal forces in the case of oxygen manifest themselves at about twice the distance observed in the case of hydrogen, i. e., for distances less than 7×10^{-13} cm. Such a conclusion is to be anticipated on general grounds, for presumably the oxygen nucleus is more complex and has larger dimensions than that of helium.

In his preliminary experiments, Marsden observed that the active source always gives rise to a number of scintillations on a zinc sulphide screen far beyond the range of the α-particle. I have always found these natural scintillations present in the sources of radiation employed. The swift atoms producing these scintillations are deflected in a magnetic field, and have about the same range and energy as the swift H atoms produced by the passage of α-particles through hydrogen. The number of these natural scintillations is usually small, and it is very difficult to decide definitely whether such atoms arise from the disintegration of the active matter or are due to the action of the α-particles on hydrogen occluded in the source.

These natural scintillations were studied by placing the source in a closed box exhausted of air about 3 cm. from an opening in the end covered by a sheet of silver of thickness sufficient to stop the α-rays completely. The zinc sulphide screen was fixed outside close to the silvered plate. On introducing dried oxygen or carbon dioxide into the vessel, the number of scintillations fell off in amount corresponding with the stopping power of the column of gas. An unexpected effect was, however, noticed on introducing dried air from the room. Instead of diminishing, the number of scintillations was increased, and from an absorption equivalent to 19 cm. of air the number was about twice that observed when the air was exhausted. It was clear from these results that the α-particles in their passage through air gave rise to long-range scintillations which appeared of about the same brightness as H scintillations. This effect in air was traced to the presence of nitrogen, for it was shown in dry, chemically prepared nitrogen as well as in air. The number of scintillations was much too large to be accounted for by the presence of traces of hydrogen or water-vapour, for the effect observed was equivalent to the number of H atoms produced by the mixture of hydrogen at 6 cm. pressure with oxygen. The measurements were always made well outside the range of the recoil nitrogen and oxygen atoms, which we have seen are stopped by 9 cm. of air.

These swift atoms which arise from nitrogen have about the same brightness and range as the H atoms produced from hydrogen, and ,presumably, are charged hydrogen atoms. Definite information on this point should be obtained by measuring the deflection of a pencil of these atoms in a magnetic and electric field. The experiments are, however, exceedingly difficult on account of the very small number of scintillations to be expected under the experimental conditions. It should be mentioned that the evidence so far obtained is not sufficient to distinguish definitely whether these are H atoms or atoms of mass 2, 3, or 4, for the range and brightness of the latter would not be very difrent from those shown by the H atom.

It is difficult to avoid the conclusion that these long-range atoms arising from the collision of α-particles with nitrogen are not nitrogen atoms, but probably charged atoms of hydrogen or atoms of mass 2. If this be the case, we must conclude that the nitrogen atom is disintegrated under the intense forces developed in a close collision with swift α-particles, and that the atom liberated formed a constitutnent part of the nitrogen nucleus. It may be significant that from radio-active data we should expect the nitrogen nucleus of atomic mass 14 to consist of three helium nuclei of mass 4, and either two hydrogen nuclei or one nucleus of mass 2.

The effect observed in nitrogen would be accounted for if the H nuclei were outriders of the main nucleus of mass 12. The close approach of the α-particle leads to the disruption of its bond with the central nucleus, and under favorable conditions the H atom would acquire a high velocity and be shot forward like a free hydrogen atom. Taking into account the great energy of the particle, the close collision of an α-particle with a light atom seems to be the most likely agency to promote its disruption. Considering the enormous intensity of the forces brought into play in such collisions, it is not so much a matter of remark that the nitrogen atom should suffer disintegration as that the α-particle itself escapes disruption. The results, as a whole, suggest that if α-particles or similar projectiles of still greater energy were available for experiment, we might expect to break down the nucleus structure of many of the lighter atoms.

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This, the first issue of *The Armour Engineer,* appears as the effort of a new staff, after a period of one year, during which *The Armour Engineer* suspended publication in order to make way for more important military matters, which were, a year ago, uppermost in our minds. Now that affairs of the world are swinging back toward their normal conditions, it is the purpose of the staff to place this journal again among the foremost of the college publications. The policy, as of previous years, of publishing a high standard of engineering articles written chiefly by Alumni and Faculty members of Armour Institute, will be continued. Also, the activities of the engineering society branches are recorded, together with a section of college activities. Each society is represented with the record of the minutes of the meetings and social activities. In this issue appears a preliminary list of theses which have so far been selected by members of the senior class. Additions to this list will be published as they are available.

The Armour Engineer serves as a link between our Alumni, the Faculty, and the students, and owes its very existence to their support. For this reason any suggestions for the purpose of increasing the value of *The Armour Engineer* to our readers will be greatly appreciated by the editors.

IN MEMORIAM.

MRS. JULIA BEVERIDGE.

Mrs. Julia Beveridge, 32 years in service of Armour Mission and Armour Institute of Technology, met with a fatal accident on June 19, 1919. A Ward bakery auto wagon collided with her, knocked her down on State and 33rd Streets, fractured her skull and otherwise seriously injured her. Operation at St. Luke's Hospital by Dr. William Harsha, Sr., was undertaken at 6 a. m. June 20, 1919; about 8:15 a. m. she expired, not having regained consciousness from the morning of the accident. Funeral services were held at Boydsten Brothers Chapel, 4227 Cottage Grove Avenue, at 3 p. m. Sunday June 22d. Remains were taken to Geneseo, Illinois, on Monday at 7 a. m., June 23d. Interment took place in the family lot at Geneseo, Illinois.

Mr. Joseph F. Armour, a member of Plymouth Church, younger brother of Mr. Philip D. Armour, founded the Armour Mission in 1886. Before completion, his demise took place, and Mr. Philip D. Armour finished the Armour Mission building in 1887, where very many of the Plymouth Church workers and Sunday School attendants took up the work of Armour Mission Sunday School. A library was provided in the Mission Building and Mrs. Julia Beveridge, for several years attendant of Plymouth Church, was appointed as librarian in 1887, serving faithfully and endearing herself to all who came in contact with her. This work she continued until the erection of the Armour Institute of Technology in 1893, when she was made Registrar of this Institution, serving in this capacity until September, 1899, succeeding

Miss Jessie Van Vliet as Librarian of the Armour Institute of Technology until her death, June 20, 1919.

Plymouth Church	3 years, 1883-1886
Mission Library	6 years, 1887-1893
Registrar	6 years, 1893-1899
Librarian	20 years, 1899-1919

F. U. SMITH.

Mrs. Julia Beveridge needs no long eulogy in order to have her place in the hearts and memories of the students of the Armour Institute of Technology.

She was here before the first student was registered, and the student who entered last, while her presence graced and dignified our Library has part of her biography in his mind also.

The outstanding lesson from Mrs. Julia Beveridge's life and its investment with its large success is this—nothing can be estimated for its full value until it is done well. In the work of the Armour Mission, which was small and yet critically valuable for the wandering boys of this polyglot neighborhood, this woman with her good helpers, such as Helen Cary, made the Babel which assembled at night in the little wood-working class on the corner, into a Pentecost. They met there as the people of Babel, took part on all other efforts, with great confusion of speech; and then, by her influence, they attained unity of feeling and hope, and each understood the other in the language in which he was born. Practical democracy never had more of a trial than on those nights, when these jangling bells out of tune, were made to be in tune by her harmonizing influence. When she was supplied with excellent tools and larger opportunities, the dissevered grains of sand which these highly individualistic boys represented were melted together into a transparent success sociologically. She never dreamed that she was doing one of the greatest things, and this on the opening of one of the fiercest controversies on the value of practical democracy, but she was not only doing this, and doing it well, she was laying the foundations of the Armour Institute of Technology.

I make bold to say that if Julia Beveridge's work had not been so valuable to those boys, some of whom are now middle aged men, and had not enthralled the heart and opened the eyes of Mr. Philip D. Armour to the capacity of these aimless creatures to receive such valuable instruction and training, it is questionable if he would have thought of carrying the work on through its various stages, until the present plant with its buildings too seriously circumscribes what is the Armour Institute of Technology in the progress of the future. We never know who the real founders of our best institutions are, until we get back into the quiet region of the supreme forces, and it is oftentimes a woman's hand which guides not only the cradles of the world, but guides the destinies of those who are come out of the cradle. Julia Beveridge was childless, and without a son she could call her own, she had hundreds of Armour boys, who are now men, who treated her as a mother and guide in their earlier days, in the Armour Institute of Technology. I never knew her to lose the respect, reverence and loyalty of a single boy. There are others whose names are not yet starred, thank God, whose great contribution to this Institution has been charm and dignity of character or that winsome and unbendingly pright excellence, which are essential in the education of a young man. We think of the influence of our earlier days and of our latest days, of those who have not been teachers, except through the force and pervasion of sound personality. The greatest teacher is one in whose presence a student cannot think of a mean thing as possible, whether that teacher teaches with books and blackboards, or by his or her official relationship at the desk where the students are met, or in the Library where they are made to be free and strong with books.

Our Institution has been very happy in the kind of women and men who have had the hearts of our young students from the beginning to the end of their course, and have never lowered the banner or reduced the value of a high ideal for their lives as well as for their scholarship. Julia Beveridge belongs to the fine early days of Carrie Wright and Helen Page, of Mrs. Jane Bell, who lives in California, and rejoices in the Armour Institute of Technology; Rosa Lang, whose personal presence is with us yet, though she departed this life more than a decade ago; Mr. George Dietz, whose fine and artistic nature gave its quality to our boys; and most prominent of all, Mr.

Thomas C. Roney, our first Dean and our first great loss. But Julia Beveridge, and all these, indicate that there are supreme values connected with them which we can never lose, and for which we are deeply thankful.

DR. FRANK W. GUNSAULUS.

BOLSHEVISM AND THE AMERICAN SPIRIT.

BY PROFESSOR GEORGE L. SCHERGER.

At the very moment when America and the Allies were congratulating themselves on the defeat and overthrow of autocracy, a new enemy, no less formidable, appeared in Russian Bolshevism.

Fostered in Russia by German agitators, Bolshevism brought about the disintegration and collapse of Russia. But if the Russian bolshevists would seem at first to have worked in Germany's interest by detaching Russia from the Entente and by agreeing to the Treaty of Brest-Litovsk, they soon turned the tables on Germany by carrying on such an insidious and sucessful propaganda on that country that they brought about a revolt against the government which made the collapse of Germany inevitable.

Since then other countries have become alarmed at the rapid spread of the bolshevist doctrines and spirit among the laboring classes and even America today must seriously reckon with this menace. Our country—yesterday the most advanced of free nations and the greatest champion of Democracy—finds herself on the defensive, while Russian agitators tell us that our institutions are antequated and undemocratic and advise us to adopt their radical program as a panacea for all our ills. The appalling increase in prices and the cost of living is breeding unparalleled industrial unrest. The demands of the labor unions are becoming more and more radical, so that capital finds these demands unrealizable. Never was the conflict between capital and labor so fierce and intense as it is today. It seems to be a clash between the old order and the new. Almost any moment may bring a catastrophe.

This development has come with amazing celerity and finds us wholly unprepared to meet it. We have been so busy helping

European nations extinguish the great conflagration over there that we failed to see that our own house was taking fire. We had become so prepared for war that we were totally unprepared for peace when it came. The long absence of the President in Europe and other factors delayed the formulation and the carrying out of a program of reconstruction.

The new situation we have to face and the new problems we have to solve find us dazed and bewildered by their complexity. Writers and speakers are still fighting militarism and the Kaiser and seem unable to meet the new issues.

In the meantime the radicals have been busy instilling their poison into the minds of the laboring classes. They are singing their siren's song before willing listeners. It will not help us to denounce or even deport them. We must meet them in the open forum by combating their fallacies. Denunciation is not argument. All enduring victories are fought and won in the mind. We must discover and defeat the errors of the bolshevist argument if we would triumph in the end; otherwise our supposed victory will prove to be but a truce.

Bolshevism is revolutionary socialism. It is a combination of two opposite and usually irreconcilable ideas—socialism and anarchy. I call these two tendencies antagonistic because anarchy implies the overthrow of all government and authority, while socialism signifies the entire subordination of the individual to the State and the greatest possible amount of government centralization and control. The marriage between the two ideas is only temporary. It will cease as soon as Bolshevism triumphs. In other words, Bolshevism is extreme or radical socialism that will not wait for victory by orderly revolution, but desires the immediate overthrow of the existing order and does not shrink from using any means to disintegrate and destroy, so that it may erect a new autocracy upon the ruins. It accepts without scruple the idea that the end justifies the means.

The Bolsheviki profess to believe in democracy, but it is an extreme democracy that aims to level down instead of raising up. It is a democracy that aims to secure absolute equality, and procribes all who through industry, thrift, and ability have raised themselves above the average level. Merit and excellence, instead of being encouraged and rewarded, are treated with hostility. The entire system is designed rather for the lazy and the defective than for the industrious and the able. Such a system has nature against it. It would prevent progress and lead to fossilization. Progress comes largely through the work of great leaders rather than through the merits of the crowd. It is the few leaders who find the way. The mass must follow, not lead. The aim of nature and of civilization is to encourage and develop excellence, not to bolster up mediocrity. It will ever be impossible to stamp out inequality of ability. To do so would be a calamity.

While Bolshevism, like Socialism and other forms of Communism, has a wrong notion of what Democracy really means, it also has an erroneous idea of individual liberty. Indeed it would prove subversive of liberty. The individual at every turn would find himself tyrannized over by the state. He would lose all initiative because there would be no incentive to exert himself when the laziest and least gifted individual thrives as well as the most industrious and most highly gifted. From the cradle to the grave the individual would be under the direction and domination of the state.

Bolshevism and every form of Socialism is foreign to the American spirit. We Americans are individualists. Our deepest craving is for liberty. Our nation has flourished because we have trusted the individual and given him more elbow room than any other country. American push and initiative are the very foundation of our greateness and success. We must not permit any infringement of the freedom of the individual. Our laborers should be made to see that the new radicalism means that we give up our former ideals and strike out into new paths. They should realize that Socialism is a mirage; that it would bring about industrial disaster; that it would impoverish instead of enrich the workman; that it would subordinate him to the state and subvert his liberties. The best antidote aginst Bolshevism is a strong dose of Americanism.

The eyes of the world are upon America today. Our country is the battleground of the new ideas and the old. At the opening of the great war both sides seemed to realize that the decision of America would settle the conflict and therefore moved heaven and earth to influence our decision. So again today every great or crazy notion must be tried on us. Even though America has become the storm center of the world and is today torn with unrest and strife, I believe in the ability of the American people to settle the new difficulties in a peaceful manner. We must solve the problem of how to make life more worth leading for the average man. The solution of this problem will be the most significant thing America has ever accomplished.

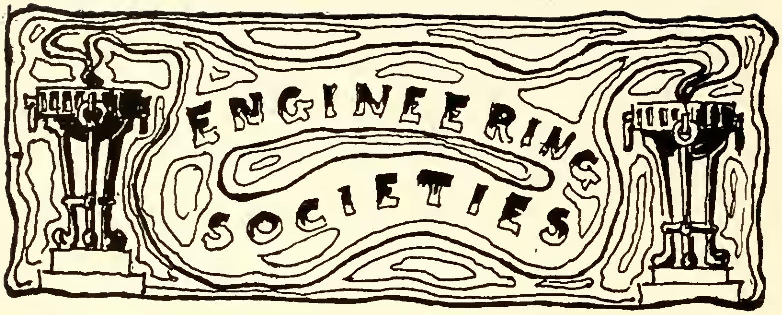
TO THE FRESHMEN.

I suppose that most Freshmen enter Armour with the idea that their great object here is to soak up all of the facts and theories that science has accumlated for them through the ages. Thus equipped with the vast store of knowledge, patiently acquired trough study, experiment, and analysis by the wise men of many centuries, he hopes to fare forth into the world of engineering and endeavor to pour out his treasure in great engineering enterprises.

Nothing can be farther from the real purpose of engineering education. No mere encyclopedia of facts thoroughly memorized can make out of a man more than a human card index. No employer has any use for a man whose mind is stored only with facts, formulae, equations. He can buy a handbook for $5 and have all of these and many more for immediate reference. No, the only value anyone can attach to these facts is to *know what to do with them.* The student should learn as soon as possible to think logically, so as to be in the best position to attack a new problem. His first concern is "What do I want to do with it?" and then "What is the first step toward accomplishing the result?" There is only one way to attack a problem, and that is to appraise all of the known quantities, substitute them in the equations that apply, and then by processes of elimination and consolidation, make the unknowns disappear.

The great value, to my mind, of an engineering education consists in the ability it creates in the student of solving any problem presented. After four years of daily grappling with new problems, most of them unheard of and unimagined by him, the student learns that any problem can be solved; even if he cannot solve it, someone can. He is thus equipped with that invaluable quality, fearlessness, willingness to undertake any task that requires patience, determination, originality and logical thinking, knowing that its solution is possible and that he can achieve it.

Summng up, the thing to do is to study the *application* of the facts discovered for you by your predecessors and prepare to go farther with them. Remmeber that the professor can only guide you, and that you must rely on your own initiative and energy to make yourself sucessful. W. G. Smith.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President	Ellis C. Cook
Vice-President	I. J. Bready
Treasurer	H. C. Peterson
Secretary	W. N. Erickson

The first meeting of the year of the Mechanical Engineering Society of the Armour Institute of Technology was held on September 26, 1919. In previous years the meetings of the society have been held evenings. This year, however, a plan was devised whereby meetings could be held during the day. This plan will work out very successfully with the assurance of a large attendance at our meetings. Sophomores and Freshmen will also be able to attend the meetings as guests of the society.

President Cook called the meeting to order and gave a short talk concerning the work, object and organization of the A. S. M. E.

The Treasurer's report was read and accepted.

Professor Gebhardt addressed the society and impressed upon those present the value of being able to address an audience with an impromptu talk. He also brought forth the fact that one should get away from that self-conscious feeling when address-ing an audience. He also told the society that it is essential that good English be used at all times in talks and papers. Professor Gebhardt also discussed the offers and reports of the parent body of the A. S. M. E., concerning the meeting of the societies at the various colleges.

President Cook called upon Mr. Bready for a talk and Mr. Bready responded with a talk on water purification. Mr. Bready described the Ziolite process of water purification. It was a very interesting talk and gave the society an insight into the value of water purification for certain commercial processes. Mr. Stone also gave a short talk on the spirit and the value that one could receive from the A. S. M. E. At this meeting it was decided that our next meeting be held in the form of a smoker.

On October 22 a smoker was held in Chapin Hall, to which the society turned out in a body. A large number of Freshmen and Sophomores also attended. Refreshments were served, and all those present had a very delightful evening.

The society decided that its policy this year would be to have the President call upon the members for talks upon any subjects they would wish to talk about. Occasionally papers will be read and the society will be addressed by outside speakers. It is the belief of the society that the greatest value can be secured from the A. S. M. E. by conducting its meetings along the lines of the policy decided upon.

Wm. N. Erickson,
Secretary.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF ELECTRICAL ENGINEERS.

Chairman	W. M. Seyferlich
Secretary	H. D. Stevers
Treasurer	J. Smely

The first meeting of the Armour branch of the A. I. E. E. was held on the first Tuesday in October, for the purpose of electing officers.

Mr. Seyferlich was elected for the office of chairman, with the unanimous vote of the fifteen members present.

Mr. Stevers, who was known as Ensign Stevers for the past two years, was elected to the office of secretary, while Mr. Smely was honored with the treasurer's position.

After the election of officers, the eligibility of prospective members, and the possibility of having motion pictures for educational purposes were discussed.

On Tuesday, October 21, the second meeting was called, and more than fifty electrical students attended. At this meeting, Professor Freeman, professor of Electrical Engineering at Armour, and member of the American Institute of Electrical Engineers, pointed out, in a very interesting manner, the advantages and benefits of being affiliated with such an organization.

After Professor Freeman's address, plans were formulated for a smoker, and it was decided that all regular business meetings of the organization would be called thereafter on Tuesdays at four o'clock.

More than two dozen Armour men, including Professors Freeman and Penn, as well as several of the Alumni, attended the joint meeting of the Chicago Branch of the A. I. E. E. and the Electrical Engineering Section of the W. S. E., held at Fullerton Hall, Art Institute, on Wednesday evening, October 29.

The speaker of the evening was the illustrious Dr. Charles Proteus Steinmetz, Chief Consulting Engineer of the General Electric Company, and one of the greatest living engineers.

Dr. Steinmetz dealt with the all-important subject of "Power Supply and Generation of the Future," and compared in a most interesting manner the three available sources of energy: Coal; water-fall, and solar energy.

He pictured the annual output of coal in the United States in the form of a "defensive wall," surrounding our entire country on all four sides; a wall, as thick and as high as the noted defensive wall of China. In terms of the great pyramids of Egypt, he stated that more than a hundred of the largest pyramids ever constructed, could be built with our annual output of coal.

Dr. Steinmetz next pointed out the fallacy in the popular idea that were the available sources of water power in the country properly "harnessed," sufficient energy could be obtained to supplant that of our annual coal supply. He showed that with the highest possible efficiency the maximum available energy from water power in the United States would not amount to one-fourth of the energy of our yearly coal consumption.

In discussing the power supply of the future, Dr. Steinmetz told of the tremendous amount of available energy in the sun's rays, commonly known as solar energy. He commented on the so-called solar engine, the development of which has been very limited, in fact it was stated that there has been practically no progress in this line up to the present. A clear idea of the vast amount of energy available in solar energy in the United States presents itself when one considers the comparison presented by Dr. Seinmetz. Assuming that our present means of coal consumption be improved and developed to such an extent that the efficiency of the apparatus be raised to twenty per cent, and assuming on the other hand that we have a solar engine with an efficiency of ten per cent, the total available energy in the annual output of coal in the United States would amount to approximately one hundredth of the energy output of such a solar engine using the available solar energy.

Dr. Steinmetz did not overlook the winds and tides in his discussion, referring to the sources of energy for the future. With reference to the wind, he suggested the possibility of installing wind driven induction generators on our great transmission towers in order to utilize the energy which ordinarily goes to waste, and thus convert it into electrical energy. It was also intimated that the future engineers may realize the necessity of building a large network of induction generator stations driven by wind and water power. "Hundreds of such small induction generating stations would then feed into the system over collecting lines, just as hundreds of induction motor installations receive power from it over distribution lines, and a large synchronous main station—steam turbine or hydraulic, or possibly even merely a synchronous motor station—would control the voltage and frequency of the system.

Upon the close of the address, various phases of the subject were discussed and the great master of engineering enlightened many on different questions concerning more economical modes of generation, transmission, and consumption.

It was emphasized by Dr. Steinmetz that the present wasteful use of coal could be somewhat eliminated by interposing a turbine induction generator plant between the high pressure engine boiler and the steam heating system which it supplies. Such a unit would convert the small percentage of fuel energy available into mechanical and electrical power which could be fed into the line. However, such a system would meet barriers, in that the necessity for the services of a skilled engineer or operator, and the addidtional expense unergone by the power supplying company would more than offset financially the value of the amount of energy saved.

Among the other important subjects discussed were: The possibilities of obtaining energy from coal directly, as in a battery; the possibilities of transmitting energy and power by wireless; the utilization of the energy of radium; the possibilities of extracting energy from the earth's interior; and, finally, the possibilities of developing a "cold incandescent light."

The lecture itself, according to those who attended, will be placed on record as one of the most interesting, and the logical reasoning used by Dr. Steinmetz was remarkable. His accurate, clear and concise answers to the questions presented showed clearly that he was a master in his line.

The first A. I. E. E. smoker of the year was held in the Armour Lunch Room on Wednesday evening, November 5th, and more than thirty-five electricals were present.

The speakers of the evening and their respective subjects were as follows:

Professor Freeman—"The Qualities of the Successful Engineer."

Mr. E. C. Lang, Armour '14, Consulting Engineer— "What Is Expected of the College Graduate."

Mr. R. E. Fischel, Armour '13, Secretary and Treasurer, U. S. Auto Supply Co.—"Choosing a Vocation After Graduation."

Professor Freeman corroborated many of the statements made by Dr. Steinmetz at the assembly and with the aid of illustrations, pointed out the most important qualities in the successful engineer and the manners in which they might be developed. Small charts were distributed on which the various qualities were listed by the larger electrical companies, such as given by the

General Electric Company and Westinghouse. A system of grading was suggested, using one of the above lists as a reference.

Referring to the lists distributed by Professor Freeman, Mr. Lang told of some of the things expected of the college graduate, while Mr. Fischel presented an interesting talk on "Choosing a Vocation After Graduation."

Dean Monin and Professor Freeman were commended highly by both speakers for their "fatherly advice," and each speaker attributed his success to his social relations while at school rather than his particular technical education.

The addresses were immediately followed by a "smoke and eat-fest," and while the busy eaters were heavily indulging in sandwiches and coffee, Mr. Smely captured the final applause of the evening by presenting a humorous paper. Everybody left in a happy mood and with a full stomach.

THE CIVIL ENGINEERING SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

President	A. Stein
Vice-President	H. Anderson
Secretary	E. Dasing
Treasurer	J. Frank

The first meeting of the year of the Armour Civil Engineering Society was held in the Mission Building, Monday, October 13.

Professor Phillips called the meeting to order. A. Appelbaum was elected temporary chairman and the above officers were then elected, also temporary.

It has been the aim of this Society for the past year to affiliate itself with some well-established society of engineers, and the Western Society of Engineers has now been chosen for that purpose.

Preliminary action was finally taken at this meeting to have the President appoint a committee for the purpose of drafting a new Constitution and By-Laws in connection with the affiliation of this Society as a Student Branch of the Western Society of Engineers.

At its second meeting, this new Constitution and By-Laws was accepted by the A. C. E. S. and it is now pending the approval of the Board of Directors of the Western Society of Engineers. Upon the acceptance by the latter, there will be a new election of officers.

It is planned for the coming year to be present as a body at appropriate meetings of the W. S. E. Smokers and other local meetings of engineering interest are proposed.

Emil Dasing.

THE CHEMICAL SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

E. G. Vogt	President
E. F. Winter	Vice-President
W. J. Bentley	Secretary
P. J. Stern	Treasurer

The A. Ch. E. S. has been organized and will have one of its most successful years. The committee has prepared a fine list of lectures and can promise an interesting and instructive talk at every meeting.

The Sophomores and Freshmen are cordially invited to attend the meetings of the Society. It will be a fine opportunity to hear men prominent in the Chemical Profession talk freely of their work and will be another chance for all to get together and develop a more active interest in the Chemical Industry. Meetings will be held two evenings in the month at the Institute. It is planned to have the first meeting in the form of a "Smoker" and we hope to see a full attendance.

We welcome Professor Tibbals back to our midst from his war duties and feel sure that both he and Professor Freud, who returned last semester, will have much of interest to tell the Society. Both were commissioned as Captains in the Summer of 1918. Professor Tibbals was in charge of Research Work for the Ordnance Dept. and Professor Freud served with the Chemical Warfare Service, A. E. F. We also wish to congratulate the students who have returned to their courses from the service. They have certainly brought back with them a fund of new ideas and a spirit and determination which will raise the standard of the Society.

The Department has secured the aid of two new Instructors and we feel sure, from our present regard for them, that we will soon achieve the same basis of respect and good fellowship we have with the other Instructors.

Mr. Dean, our new teacher in Metallurgy, graduated from the Missouri School of Mines, with the degree of Bachelor of Science, and the following year obtained his Master's degree. He has served as Assistant Instructor in Physical Chemistry at Harvard, has held a Chemical Fellowship at the University of Chicago and was an Instructor in Metallurgy at the University of Pittsburgh. He was later employed by the Zinc, Lead and Smelting Co., and was with the "Anaconda Copper Co." when Amour claimed his services.

Mr. Smith will assist Dr. Gill in keeping the Freshmen interested in Chemistry. After a year at the University of Cincinnati, he changed to Purdue, where he received his degree of Bachelor of Science in Chemical Engineering. He has had extended experience in Road Construction and came to the Institute from the Illinois Steel Co.

The Chemical Engineering Department is the most popular and fastest growing department in the Institute and the Faculty has been hard put to find room for all the students. Quite a little new equipment has been purchased and plans are being completed for a building to house the entire department and provide sufficient facilities and room for expansion.

Walter J. Bentley.

ARMOUR RADIO ASSOCIATION

The Armour Radio Association, with the assistance of Prof. Guy M. Wilcox, has been organized and held its first formal meeting at Armour Institute of Technology on Oct. 16, 1919, with an attendance of twenty-four members. Officers were elected for the coming year as follows:

President	H. D. Stevers
Vice-President	V. L. Cooley
Chief Operator	A. R. Mehrhof
Secretary	R. J. Grant

The Association is a revival of pre-war Radio at Armour and promises, through the prestige and practical experience of its members, to make a name for itself both in amateur and commercial circles. By no means, however, are its ends in any way commercial; but it aims, by means of the technical knowledge of its embryo engineers and its access to the schools' unsurpassed radio equipment, to construct a wireless station equal if not superior, in point of design and efficiency of operation, to any commercial station now in existence. The development of this high ideal will, of course, take time and the continued personal endeavor of every man in the Association. The very fact that the end is hard of achievement is the bulwark of success, when each man is working to the same end; for a growing organization is ever strong; unity means strength and in strength there is development and progress.

The fundamental purpose of the Association is to foster radio experimentation among the "bugs" at Armour; to light the way with its example and influence, by which radio amateurs may make themselves into a stronger and more effective class of scientists, and to prove to the government of the United States that radio amateurs as a class are worthy of recognition and corroboration. Although lone amateurs, with the necessary amount of patience, can make quite fair progress hitting the bumps of radio, still, it is evident that he could go much further into the realms of the sparks and electron, if, thru a knowledge of his associates' experiences, he could avoid the pitfalls in his path and lay out for himself a definite road.

With this end in view, a program for procedure at meetings has been arranged, whereby any difficulties encountered in radio work, any new methods employed or any discoveries made, may be brought up before the body and discussed. Anyone having previous experience along the line in question or anyone with ideas on that subject will speak his views and throw what light he can on that subject, incidentally training himself in the art of public speaking. It is a fine thing for an engineer, with his technical training behind him, to be able to tell, clearly and forcefully, his ideas on a subject to an audience of his professional brethren, and when a man specializes on some particular point in his work, it is certainly of great advantage and interest to his associates to know of the results of his endeavors. To this end, as it is the practice among technical societies, encouragement will be given to all members to present papers before the Association on any subject pertaining to radio.

With these ideas and aspirations in mind, it could not be termed overconfidence to predict that the Armour Radio Association with the widespread fame of the Institute behind it, may soon rank as the country's leading organization in the development and applications of the principles of wireless transmission.

Richard J. Grant, *Secretary.*

THE ARMOUR ARCHITECTURAL SOCIETY

The old Ecole is back and at its best again, since the thinning of the ranks by the demon Mars and is now running with all sail set and prospects of the brightest and most prosperous year she has ever known.

The upper classmen remaining loyal to the class of '20, returned to a man and managed to bring with them a few men of earlier classes, yet to receive the sheepskin.

It was certainly a gratifying sight to the old men, on the afternoon of Sept. 9, 1919, when they wandered into the Freshmen room and saw all the old seats occupied by as energetic and artistic bunch of young prodigies as was ever witnessed there before.

After the first meeting of the A. A. S. had been brought to order through the efforts of Chairman O'Connor, the following officers were duly elected:

Massier	Mr. P. Steinberg
Secretary	Mr. J. A. Karlson
Treasurer	Mr. G. Larson
Press Representative	Mr. W. J. O'Connor

Steps were immediately taken to make the school year of 1919-20 a banner year in so far as the A. A. S. was concerned.

We are looking forward to great events when we put the wild but willing bunch of Freshmen thru the A. A. S., which is to take place Nov. 24th. Although several of them have witnessed the horrors of the World War, there still no doubt remain some forms of torture that will curdle their blood and weaken their knees.

The Engineer will be curious to learn that we have six Coeds in our Department and that Miss Fassett has broken the old tradition that no Coed stays longer than the Sophomore year, by showing up on Sept. 9th to start her Junior year.

The men are making a big name for the Chicago School of Architecture in their outside work with architects on the big "Stadium" competition now being held.

Owing to the combined efforts of the Faculty and students, the School is developing some fine material for the Architectural World, which results in a large demand for Armour men by architects of the city with whom we have a high standing.

Since the beginning of the new year, the Seniors have developed somewhat along a new line—"The Art of Clay Slinging." In fact, they have become so proficient that Danforth finds but little time between dodging the leaden missles and retreating thru the door, to finish his cast. Some of the fellows say that he will finish sometime.

Mr. Campbell is not wholly in favor of our new form of entertainment and exercise and threatened to give the next offender two weeks' vacation. But the boys don't mind; they know Campbell and his two weeks.

Owing to the fact that the architects are such strenuous workers, and dutiful students, the Institute has provided the time, place and means of a little exercise and entertainment, which generally takes on the form of dancing. A half an hour or so of this sufficiently inspires a man for a full afternoon of conscientious work.

We are also pleased to announce the expansion of the Burnham Library for the personal benefit of the architects, who realize its importance in their successful study of the art.

W. J. O'Connor.

ARMOUR INSTITUTE OF TECHNOLOGY LIBRARY

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Bedell, Frederick. Air Plane Characteristics.

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Eccles, W. H. Wireless Telegraphy and Telephony.
Ellis, Carleton. Hydrogenation of Oils. 2nd edition.
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Erskine, A. R. History of the Studebaker Corporation.
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Fay, Henry. Microscopic Examination of Steel.
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Folwell, E. P. Sewerage. 8th edition.
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Fryer, R. C. Classroom Lecture Notes, Automotive Starting, Lighting and Ignition.
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Gillette, H. P., & Dana, R. T. Handbook of Mechanical and Electrical Cost Data. 2nd Edition.
Goldsmith, A. Radio Telephony.
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Putnam, J. W. Illinois and Michigan Canal.

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Turnearure, F. E., & Mauer, E. F. Principles of Reinforced Concrete Construction.

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U. S. Army Signal Corps. Radiotelegraphy.
U. S. War Department. Auto Mechanics and Auto Drivers' Instruction Manual.
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THE ALUMNUS

Being that part of **The Armour Engineer** devoted to personal mention of the Graduates of the Aromur Institute of Technology and to the affairs of the Armour Alumni Association.

Communications should be addressed to John J. Schommer, 33rd and Federal Streets, Chicago, Ill.

At the Spring meeting of the Alumni Association the following officers were elected:

James, Sidney	President
Penn, J. C.	Corresponding Secretary
Nachman, H.	Treasurer
Schommer, John J	Secretary

The Board of Managers is as follows:

Grover Keeth
J. C. Penn
M. S. Flinn
W. B. Pavey
G. M. Siebenaler
R. Henderson
W. J Baer
B. S. Carr
R. R. Harris

Class secretaries are being chosen to aid in securing correct addresses of former students.

The officers of the Alumni Association will meet soon to vote on the date of our next big gathering of Alumni, which will be some time in December.

John J. Schommer, *Secretary of the Alumni Association.*

The Armour Engineer wishes to keep in touch with the activities of all the Alumni in their engineering work. Have you changed your situation within the last year? Have you been promoted? Have you traveled? Let us know about it, or tell it about some other Alumnus. We wish to know of your successes and those of your former classmates. Write either to The Armour Engineer or to J. J. Schommer, 33rd and Federal Streets, Chicago.

COLLEGE NOTES

Athletics in Armour Institute of Technology have been revived, and the general student body is again looking forward to a successful season in all major sports.

The athletic world had studied with intense interest the athletic operations of the several governments involved in the war. The inestimable amount of physical training that had been accomplished over there, conduces to show, that general athletics necessarily needs to be retained by the colleges. Shortly after the abolition of athletics in the Armour Institute of Technology, the physical training which comes to the student through the medium of basketball playing, track work, and baseball, has been literally boxed up. The athletic student found it quite difficult to carry on his work in the classrooms without that preparatory practice which the gymnasium and the field had made possible before the war. And so the absence of athletics in the college began to be felt, with the result that intercollegiate sports have again found a place in the curriculum of the school, wholly supported and maintained out of a fund provided for that purpose by the benefactors of the Armour Institute of Technology.

The re-inauguration of athletics in the college, opens up the door to great things in "Sportsville." Out of the morbid past there appears a newer, brighter era. The practices of the armies for battle have faded away with the suffering of the sorrowful people of Europe, and in their stead, the average man is being trained to conquer the difficulties of the business world. This great object is being accomplished through athletics. American blood has been relieved of its intensely high temperature for war, and reduced to a normal state of peace and prosperity. The soldier-student has returned to his college and university with renewed vigor to continue his studies. His goal is success. The members of the faculties of the various colleges, too, are more clearly understanding the requirements of the general student body. The pre-war method of study without diversion or opportunity for physical development, has been removed from the program of the future. Intercollegiate athletics in the colleges have sounded the keynote to accomplishments in Sportsville which were impossible under the old regime. The student's hands have been untied, so to speak, and the influences of the old-fashiond world are losing their strength. The student is free to participate in all forms of sports of which the average collegiate curriculum are susceptible, and, aside from the re-establishment of athletics in the Armour Institute of Technology, through the kindliness of Professor Monin, Professor Raymond, and Mr. Smith the executive council have seen fit to support *intercollegiate* athletics.

The future of the Armour Institute of Technology in athletics is not definitely decided upon. However, there is in progress, at this writing, an interclass basketball tournament; the purpose of this competition is to uncover the best athletic material in the college for the Varsity Team. The writer has so far observed, with great interest, the skillful playing of the various classes in the tournament, and is free to say that the College Coach will have no difficulty in his determination of the very best players for college representation. The manner in which the players have undertaken their work in the tournament, and the unexcelled class spirit which has gripped every participant, is evidence of a more determined group of men than our athletic department has ever experienced. The names of many players are carefully tabulated in the writer's mind, all of whom are iron-jawed fighters for interclass supremacy, and fine material for intercollegiate activity. The tournament is doing much to bind together the respective classes, and the constituents thereof.

All interested eyes are turned toward the program for intercollegiate basketball. The writer is unable to make any positive remarks with regard to that branch of college athletics. However, a good deal of business is being transacted by correspondence, and, in view of the fact that Armour Institute of Technology has been out of the "run" for sometime, the program for basketball is being formulated with much difficulty. It must be remembered, too, that most of the colleges, with the exception of a few, have completed their schedules for the coming year. Others are the members of organized Conferences, and cannot accommodate us.

The students of the Armour Institute of Technology may be interested to know that at the recent meeting of the Board of Athletic Control it was decided to re-establish intercollegiate sports on an independent basis. Intercollegiate athletics on an independent basis merely means that instead of belonging to any Conference, such as the Little Five, or The Nineteen, our activities shall be confined to competition with colleges not bound to nor seeking to bind us with any organization. Pursuant to such arrangements of athletics in the College, our activities will have been free from the critical observation of any organization or Conference. Our success in intercollegiate basketball, baseball, or track, should assume the personal significance which every college enjoys. Personal success is not obtainable under the Conference system of intercollegiate athletics. In order that our plan for the future may measure up to the standard which we are inclined to give to it, the students everwhere in the College, regardless of scholastic denomination, must lend their support in this movement. We can move forward only by having the students move with us! They should realize that the re-establishment of athletics in the College on an independent basis is a victory for the student body.

In conclusion, the writer desires to urge the students of the Armour Institute of Technology to carry on with those who are red-blooded enough to support their College. The greatest success in athletics comes only when the scholastic forces of the College mobilize and move in the direction of "success." There should be no broken ranks in our Army of Students. They are being appealed to through the mute expressions of this article, to literally march together in one direction, destined for only one goal—success for Armour Institute of Technology in its new athletic undertaking.

Charles B. Goodman,
Director of Athletics.

SENIOR MECHANICAL THESES FOR 1920.

Absorption of Shock by Automobile Tires, by M. M. Jackson, and N. L. Marvin.

Analysis of Inertia Forces and Cam Design for a 150 H. P. Aeronautical Motor, by G. E. O. Peterson.

An Investigation Into the Effect of Temperature on the Tensile Strength of Ferrous Metals, by H. C. Peterson and T. W. Hall.

Construction and Redesign of a 10 H. P. Gas Engine, by M. Gottlieb, G. Henry and J. Mitnick.

Design of a Six-Cylinder 150 H. P. Aeronautical Motor, by G. P. Winkless and C. F. Peterson.

Exhaust Cam Design for Kerosene Engine.

Flow of Heat Through Pipe Coverings, by F. H. Schwartz, and A. Zemke.

Flow of Gasoline Through Orifices, by Y. M. Wong.

Heat Balance of a Hvid Engine, by L. E. Jones and E. Schwachtgen.

The Representation of Automobile Characteristics by Surfaces, by E. C. Cook and A. N. Gail.

Test of Harrington Stoker, by P. J. Adam, J. I. Bready, W. N. Erickson, R. Regensburger and J. M. Stone.

SENIOR ELECTRICAL THESES FOR 1920.

Design of an Alternating Current Generator, by S. Blomberg, and E. Renard.

Design of a Radio Telegraphic Station, by A. S. Liu and H. D. Stevers.

High Tension Line Protection, by J. Smely.

There has been recently installed in the Department of Mechanical Engineering the following pieces of new apparatus:

Navy Rubber Tester (Stanley).
Alpha Brinell Tester.
Differential Type Transformation Point Recorder.
Multiple Unit Electric Furnace.
25-pound Drop Hammer.
Harrington Stoker.
Chill Point Apparatus.
Flash Tester.
Hot Box Conductometer.
Steam Pipe Covering Conductometer.
Pyrovolter.
Adiabatic Oxygen Bomb (Parr).

Liberty 12, Hispano Suiza, and Gnome Aeronautical Engines have been ordered.

Hvid and International Hopper Cooled Kerosene Engines.

Set Taglibue Hydrometers for determining distillation fractions of crude oil.

Diesel Type Crosby Indicators.

Orifice Type Air Meter.

Taglibue Gasoline Boiling and End Point Indicators.

The Department of Chemical Engineering has recently purchased and installed the following additional equipment:

1—Electric Furnace with carbon resistance, tube type.
1—Calorimeter outfit for determining heat value of solid and liquid fuels, together with 3 acid resisting bombs foı same.
1—Ferry Radiator Pyrometer.
1—Steel Kettle lined with acid resisting enamel.
4—Steel Tanks lined with acid resisting enamel.
1—Semi-Steel Autoclave for 1000 pound working pressure.
1—Sweetland Filter, laboratory size, Trunnion type.
2—Filters of chemical stoneware.
1—Steel Kettle, steam jacketed and with acid resisting enamel lining.
1—Drying Oven, built to our own design in our own shops.
1—Saybolt Standard Viscosometer.
1—Electro-Titrometric Outfit.
14—Analytical Balances.
And various accessories for flow type of Gas Calorimeter.

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The Armour Engineer

VOLUME XI JANUARY, 1920 NUMBER 2

THE BY-PRODUCT COKE OVEN.

By Louis A. Sanford, '02.

At the present day coal ranks first as a power producer.

According to late estimates, the coal reserves of the world by continents are as follows:

	Short Tons.
America	5,627,823,500,000
Asia	1,410,487,600,000
Europe	864,412,600,000
Oceania	187,842,900,000
Africa	63,755,900,000
Total	8,154,322,500,000

The United States claims 51 per cent of the total coal of the world. Listed according to coal reserves, the principal coal-producing countries of the world are as follows:

	Short Tons.
United States, including Alaska	4,231,352,000,000
Canada	1,360,535,000,000
China	1,097,436,000,000
Germany	466,665,000,000
Great Britain and Ireland	208,922,000,000
Siberia	191,667,000,000
Australia	182,510,000,000
India	87,083,000,000
Russia in Europe	66,255,000,000
Union of South Africa	61,949,000,000
Austria	59,387,000,000

Columbia	29,762,000,000
Indio-China	22,048,000,000
France	19,382,000,000
Other Countries	69,365,500,000
	8,154,322,500,000

Coking of Coal.

Coal is coked in beehive ovens for coke only; in gas retorts for gas, coke being a secondary product; and in by-product ovens, The by-product coke oven may be utilized for production of coke or gas. As a rule, coke is the main product, gas, tar, light oil and ammonia are the by-products.

Uses of Coke.

Coke has many uses such as fuel for foundry cupolas, steaming and domestic purposes, but the principal one is its use as a fuel for iron blast furnaces. To produce every long ton (2,240 lbs.) of pig iron requires about 1,200 lbs. of limestone, 2,200 lbs. of coke and 4,000 lbs. of iron ore, varying with the grade of ore. So coke is one of the primary elements in the production of pig iron; pig iron is the first step in the steel industry; and steel is the largest industry of the world. The modern blast furnace is a brick lined steel stack about 90 feet high, receiving limestone, coke and iron ore at the top and air under pressure at the bottom, and discharging large volumes of gas at the top and molten pig iron and slag at the bottom. A fuel is required free from tarry matters, which would clog the spaces between the materials, of sufficient size to allow free upward passage of the gases and of considerable strength to support the enormous burden of the charge above.

Charcoal is used to a limited extent in small furnaces and was the common fuel in the early days when the forests covered the country. Let us look at the growth of pig iron production in the U. S. for 50 years, say 1865 to 1905. In 1865 the production of pig iron in the U. S. was estimated at 843,400 metric tons (2,204.6 lbs.) out of a total of 9,099,666 tons for the entire world. In 1905 the U. S. produced 23,340,000 tons out of a total of 54,054,000 tons for the entire world.

Coke was probably first tried as a blast furnace fuel about 1811. In 1860 only about 21 furnaces were reported as burn-

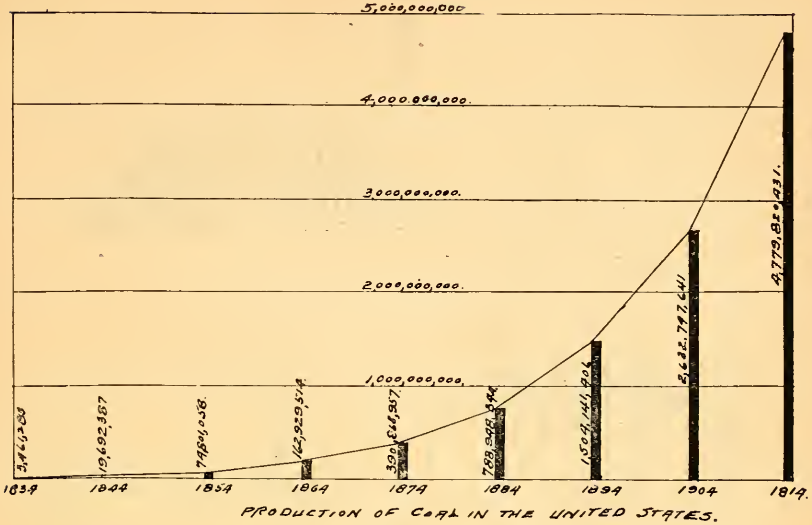

Fig. 1.

ing coke, in 1880 about 149 blast furnace stacks used it. Since then the use of coke for blast furnaces has increased very rapidly.

Coal was first coked in piles or heaps yielding about 50 to 55% coke of the coal charged. Next came the bee-hive oven, about 1841, which held the entire field until 1893, when the first Semet Solvay ovens were built in the U. S. Since 1893 the number of by-product ovens has been increasing rapidly, especially in the last five or six years and new constructions of bee-hive ovens have practically ceased.

The production of the by-product coke in the U. S. has increased as follows:

	By-Product		Bee-Hive	
	Tons	% of Total	Tons	% of Total
1893	12,850	.1 %	9,464,730	99.9 %
1918	27,000,000	45 %	33,500,000	55 %

The yield of a bee-hive oven is from 60 to 65% the weight of the coal charged, with a total loss of all gas, tar, etc., which are burned to supply heat for coking. In a few bee-hive plants means have been used to recover a portion of the waste heat.

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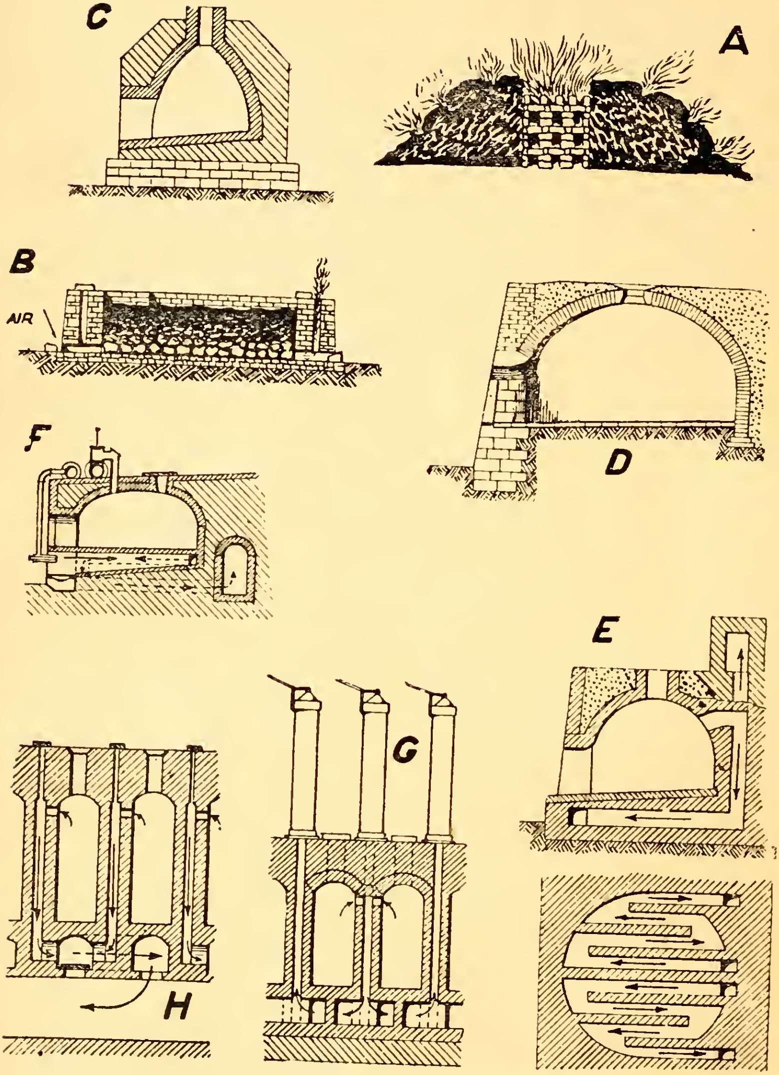
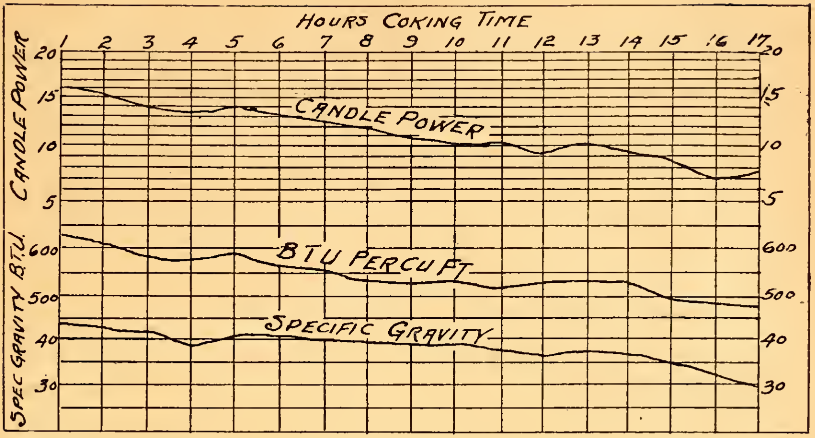


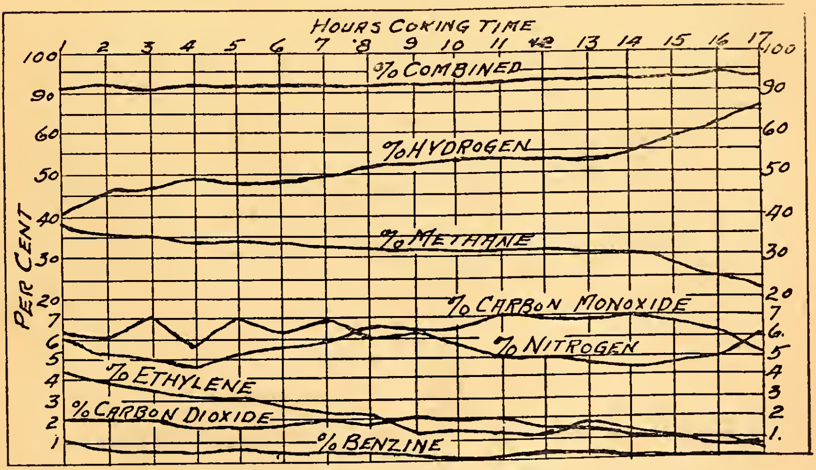
Coke Oven Evolution.
Fig. 2.



AVERAGE HOURLY ANALYSIS OF GAS FROM ONE OVEN.
COAL 25% VOLATILE MATTER.

Fig. 3.

In the by-product oven the yield of coke is close to 75% of the coal charged, 5,000 cu, ft. of gas (of about 520 B. T. U.) net (another 5,000 cu, ft. or more of gas produced being used for heating ovens), 20 lbs. of ammonia sulphate, 6 or 7 gallons of tar and about 2¼ to 3 gallons of benzol per ton of coal charged.



AVERAGE HOURLY HEATING VALUE, SPECIFIC GRAVITY, AND CANDLE POWER OF COKE OVEN GAS ANALYZED IN FIG 1

Fig. 4.

The practice has been to locate the bee-hive ovens in close proximity to the coal supply and ship the coke. Pennsylvania is the center of the bee-hive coke industry. Quite a large number of ovens are located in West Virginia and Alabama, a few in other states and one or two banks in Illinois. The latter, I believe, are not in operation.

By-product oven plants are usually located in close proximity to steel plants or cities where the gas and coke can be used or sold readily. This necessitates the shipping of coal, but facilitates the mixing of coal to produce better coke.

The modern by-product coke oven is a closed coal or coking space about 10 to 12 ft. high, 36 to 40 ft. long, with a tapered width of about 19 inches at one end and 21 inches wide at the other. This space is heated by adjoining flues entirely separated from the coal space. The ovens are built side by side in batteries of from 20 to 100 with a coal bin at the end, from which coal is carried to each oven by a larry car running on a track of top of the oven battery. On the ground on one side is a pushing and leveling machine with a wheel guage of about 30 feet. The

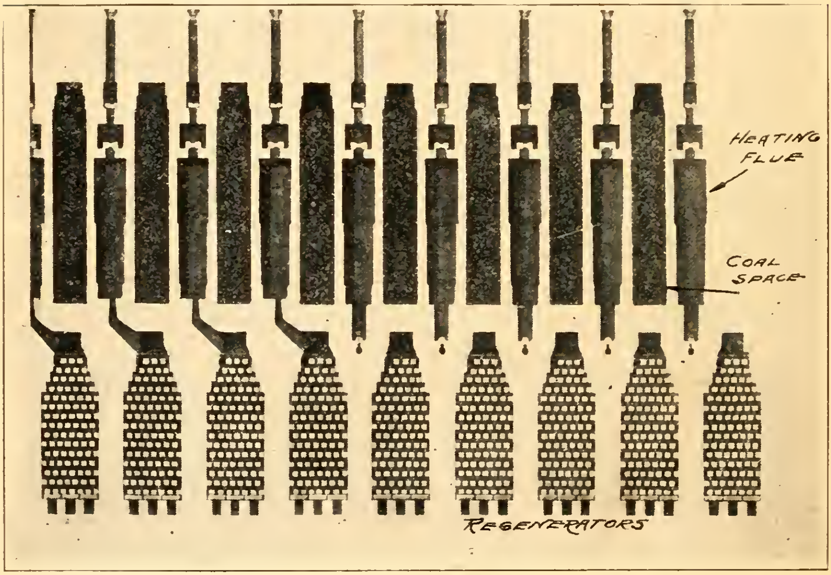


Fig. 5.
Section Showing Regenerators.

leveler bar is for leveling the coal charge in the oven to allow the gas to pass off easily to the ascension pipe, and the pusher ram on a long girder is for pushing the charge of coke out of the oven.

On the other side of the battery runs a quenching car for receiving the red hot coke and carrying it to the quenching hood to be cooled by a water spray. The coke is then dumped on a coke wharf to be fed by conveyors to the screening station.

Along each side of the battery is a narrow bench often carrying the door machines, clay carriers and coke guide. At the pusher side of the battery near the top of the ovens is the collecting main (or main for rich and lean gas) jointed to the oven by ascension pipes or goose-necks with shut off dampers or gas valves, and in turn connected to the by-product building apparatus by the suction mains.

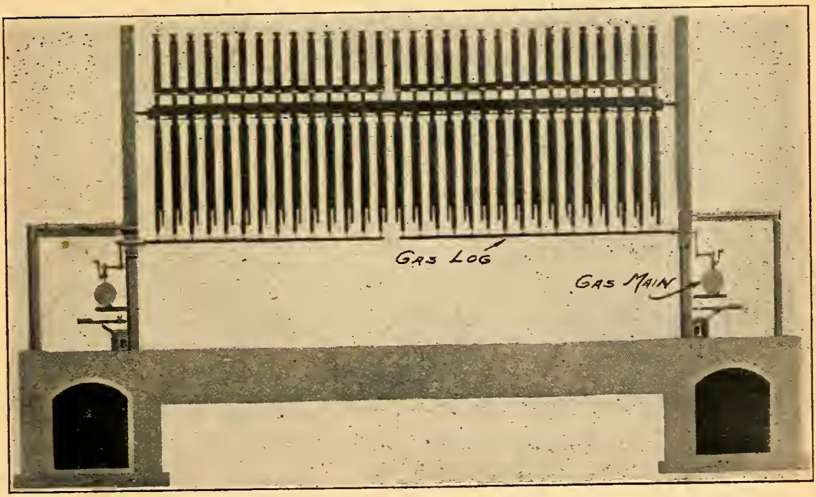


Fig. 6.
Section Showing Gas Supply.

Each end of each oven from top to bottom is closed with a door of firebrick supported in a cast iron frame. As these doors weigh about 3,000 lbs. apiece, a special machine, called a door machine, is required to remove and put them in place.

The doors are held in place by latches and luted with clay around the edges. The clay carrier is simply a moving platform with boxes for carrying clay along the benches for door luting.

ARMOUR
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After coking is complete, both doors are removed, a coke guide for guiding the coke across the bench into a quenching car is put in place at the coke side door. The ram on the pushing machine, which is on the narrow side of the oven space, is started and the coke pushed through the coke guide into the quenching car. The taper in the oven, narrow at the pusher side and a couple of inches wider at the coke side, facilitates the pushing of the coke.

It is very necessary to prevent leakage of gases between the coal space and the heating flues, as the heating flues discharge their products of combustion to the stack while the gases driven off from the coal pass by way of the ascension pipes, collecting and suction mains to the gas holder. Every precaution is taken to prevent this leakage and also to prevent leakage of gas to the surrounding atmosphere or leakage of air into the ovens. Most of the brickwork is tongued and grooved. Oven brickword is subject to considerable and varying stresses under high temperatures and therefore requires careful attention.

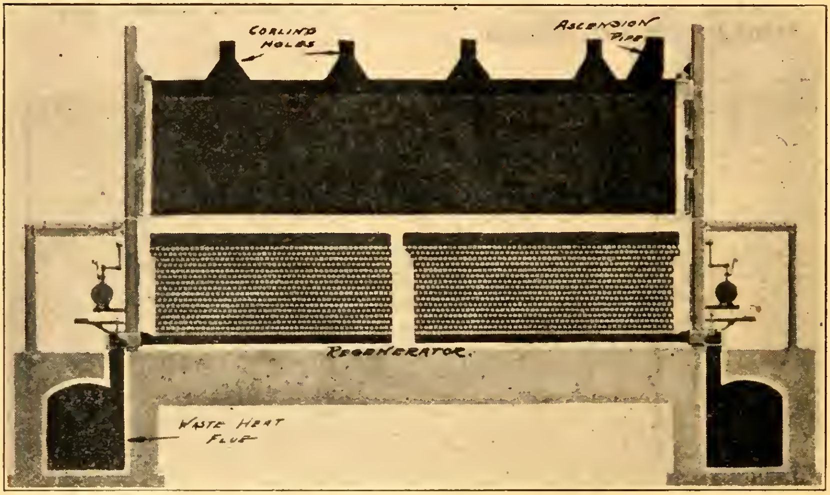

Fig. 7.
Section Through Regenerator and Coal Space.

Fireclay brick as a rule contracts at high temperatures and under load, at high temperature, deform or mush out of shape. In Europe a coke oven brick is used which neither expands nor contracts. Their ovens are smaller than ours. In the United States we use a silica brick which does not deform readily at high temperatures or under load and expands about 1/8″ per foot at oven temperatures, 2200 to 2600° F.

About six weeks is required to heat up a battery the first time, as the brickwork contains considerable moisture, which must be driven off slowly and silica brick spalls off under rapid changes of temperature. This expansion of oven brickwork is watched carefully when the battery is first heated up.

The expansion between each oven is taken care of by expansion joints i. e., open joints filled with straw and pitch or card board), so there is no expansion at the ends of a battery, which is held by a concrete pinion wall or steel buckstays with longitudinal tie rods over the top of the oven.

The steel buckstays, 12-inch I or channel sections or larger at the sides of the battery, are held at the bottom by large bolts into the concrete foundation pad under the ovens and at the top by tie rods across the top of the battery. Wood blocks and washers are placed under the nuts on the ends of these bolts and the nuts loosened slowly as the wood blocks are crushed down by the expanding brickwork while the ovens are being heated the first time. The total expansion across a battery may be six or seven inches. I understand the Semet Solvay ovens take care of their expansion in a slightly different way.

The coking of coal in a bee-hive oven takes from 48 to 72 hours; it requires about 17 hours in a by-product oven.

The first gas coming off from a coal charge is called rich gas and that coming off during the latter part of the closing period lean gas. Two collecting mains along the top of the battery are often provided, one for rich gas and one for lean, and this separation of gases is carried through the by-product and benzol plants. The rich gas passes to the city mains where high B. T. U. and candlepower standards are required, and the lean gas returned to the oven heating flues for coking the next load of coal.

The gas passes from the ovens through the ascension pipe to the collecting main then through the suction main to the primary coolers which are generally of vertical water tube boiler construction, gas outside of tubes and water inside. This cooling water, by the way, flows from the cooler to a sump and is used for quenching coke.

The gases receive some cooling in the ascension pipes, collecting mains and suction mains before they reach the coolers and part of the tar is condensed. A quantity of this, too, is pumped into the collecting and suction mains at various points, which is called flushing tar. Its object is to prevent the formation of pitch on the sides of the mains. All this tar is trapped out before or at the coolers.

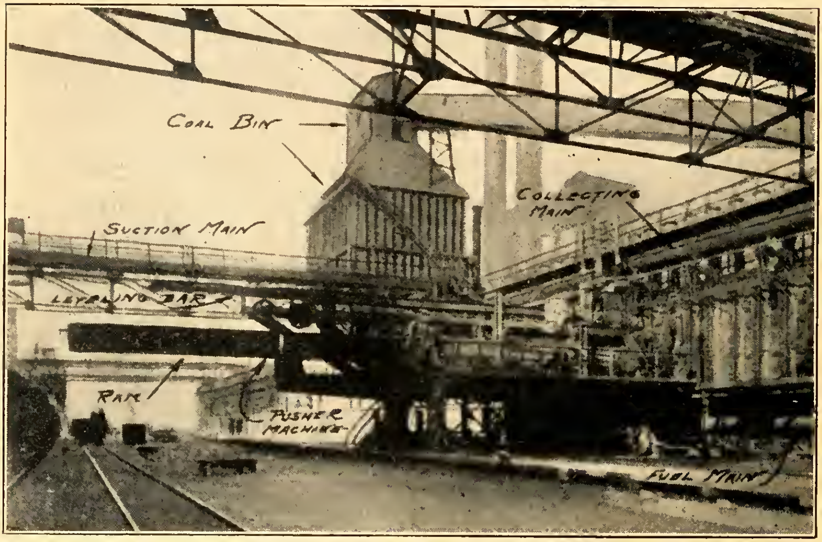

Fig. 8.

From the coolers the gases pass to exhausters, generally of the Connellsville or Root rotary type. These exhausters maintain a slight suction on all the ovens and force the gas under pressure to the holders.

The ammonia is removed from the gas by large lead lined cast iron vessels called saturators. The gas enters the saturators through a lead pipe or hood with slots in the sides; this pipe, called the cracker pipe, is submerged in a sulphuric acid bath, so the gas bubbles up through this sulphuric acid solution. Ammonium sulphate, a white salt, is formed, drops to the bottom of the saturator to be removed by an air or steam ejector, drained, dried with a centrifugal dryer and shipped for use as a fertilizer.

If the benzol is to be removed the gas is cooled again by some form of a direct contact water cooler then passed to scrubbing towers, steel tanks 75 feet high or over, filled with grids of boards set on edge close together to give a large wetted surface. The gas passes up through these grids and a light petroleum oil called straw oil is sprayed in at the top of the scrubbers, flows down over the boards and absorbs benzol, etc., from the gas. The amount or benzol absorbed is a very small portion of the total amount of straw oil used. The benzol is distilled off and the straw oil used over and over. The benzol is re-distilled for commercial uses.

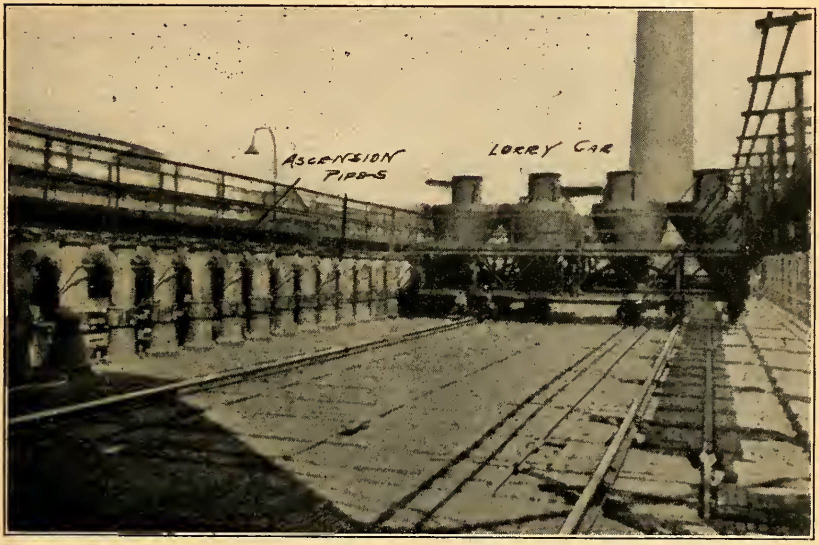

Fig. 9.
Larry Car and Ascension Pipes.

The main difference in the various makes of ovens is in the arrangement of heating flues.

The Koppers and Semet-Solvay companies practically hold the by-product coke oven business of the country. It has been the practive of the Semet-Solvay Company to retain an interest in every plant they put up and operate it, while the Koppers Company sell their plants. Two methods are used for the partial recovery of waste heat from the products of combustion passing from the heating flues to the stack. In the recuperator the lost waste gases pass through one set of tile passages and the air for combusition passes along adjoining separate passages and takes up heat through the walls from the products of combustion. The common and most efficient method of heat recovery is to pass the air for combustion through a chamber filled with checker bricks to the heat flues, where combustion with gas takes place, then out through a similar chamber filled with checker bricke. Each half hour the direction of flow of air and waste gas is reversed, the air entering through the second set of checker brick, brought up to a high temperature by the previous flow of waste gases passing to the stack. The waste gases in this reversal heat the checker brick cooled by the entering air in the previous reversal.

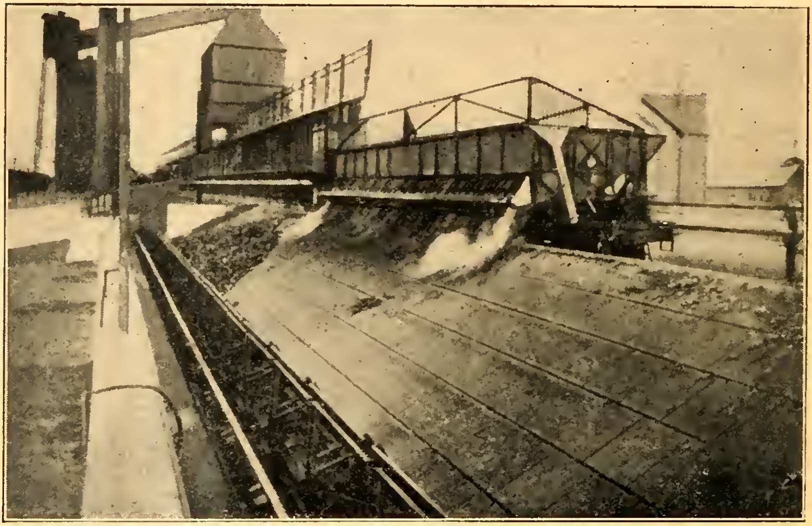

Fig. 10.
Quenching Coke.

This pre-heating of the entering air effects great saving in fuel gas necessary to heat the ovens.

The Koppers ovens are of the vertical flue type, one row of flues heating the walls of two adjacent ovens. The two regenerators are under the coal space and separated by a wall on the center line of the battery. Each regenerator is connected to the flues directly above it. These heating flues are supplied with gas from a gas log shown in cut No. 6.

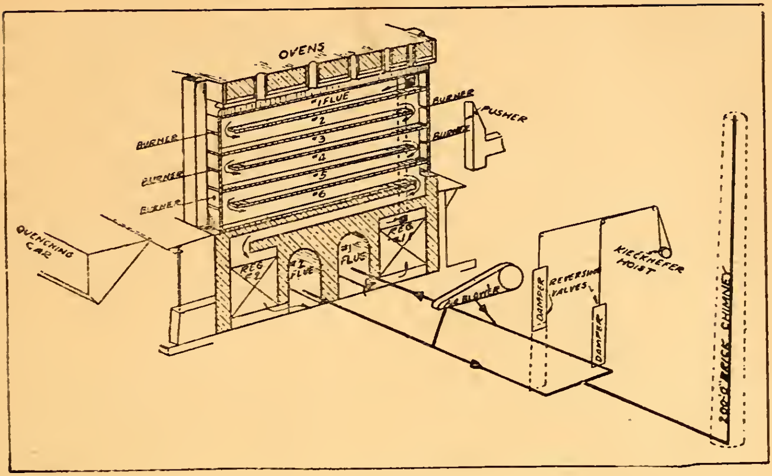

Fig. 11.
Diagram Showing the Flow of Gases and Air.

The air enters the regenerator on one-half of the oven, passes up to the flues above it, burns the gas, up across the horizontal flue at the top and down through the flues on the other half of the oven to the other regenerator, then through the waste heat flue to the stack.

The gas nozzles at the base of each flue are changed or adjusted by an iron rod passed down through the flue from the top of the oven. The air is regulated in each flue by the slide brick in the horizontal flue at the top of the oven.

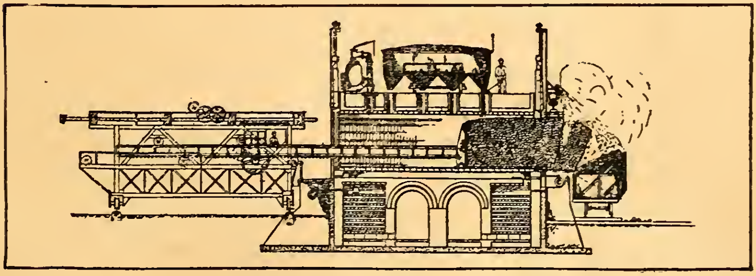

Fig. 12.
A Type of Modern By-Product Coke Oven.

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Air enters each regenerator through a cast iron tee, one leg of which connects to the regenerator space , one leg to the waste heat flue leading to the stack, and the other leg opened or closed to the outside air by a lid. A damper in this tee regulates draft through each set of oven flues.

The large waste heat flues connect to the stack at one end, the other being head-ended. Close to the stack in each of these flues are two large cast iron dampers, one for regulating the required draft and one for reversing. At each reversal, gas and air are admitted to one side of the oven and the stack connected to the waste heat flue on the other side.

In the Semet-Solvay oven, oven flues are horizontal and all connected in series. Two rows of heating flues are provided for each oven; the flow heating from one side only to the coal space. Between each oven is a heavy brick wall, in one end of which is a vertical passage connecting the end of the top flue with one regenerator. One end of the lower heating flue is connected with the other generator. Gas is admitted at each connecting bend between two flues and is not shut off at each reversal. In one reversal the air for combustion enters through the regenerator, passes up through the heating flues, burns the gases, then down through the division wall passage to the other regenerator. In the next reversal the flow of air is down through the heating flues.

In the Roberts oven the heating wall has a checker brick construction which gives a very strong wall. The flues heat from one side only to the coal space. Air passages are provided in the center wall. The oven is comparatively new, but seems to have good prospects.

WHAT AND WHY IS MALLEABLE IRON?

By H. A. Schwartz,
Chief Metallurgist, Natilonal Malleable Castings Company,
Indianapolis, Ind.

Malleable cast iron has been made for a great many years, having been invented in France about the middle of the eighteenth century. The actual industry, however, is of relatively recent growth, and has been confined quite closely to this country and to the period since the close of the Cicil War. It is now produced in the United States by a very considerable number of independent plants. The American Malleable Association, composed of manufacturers of this product, now has fifty-eight members, and there are still a fairly considerable number of producers who do not belong to this organization.

All malleable iron made in the United States is produced along the same general lines of manufacture, though there are very considerable differences of quality between the products of various firms according to the degree of skill which each producer possesses in the execution of generally similar operations. It is for the purpose of wiping out as far as may be possible such dissimilarities of quality that the American Malleable Association was formed some three years ago. This organization maintaining as it does a Research Committee and a Consulting Engineer, has been of very extreme value to the consuming interests in standardizing and improving the products of its members.

In the nature of things, this improvement has been greatest in the case of the smaller producers whose total tonnage was not sufficent to maintain the extensive staff of engineering and metallurgical advisors necessary to carry forward and continuously improve a metallurical product such as ours. At present the Association maintains what is practically equivalent to an inspection bureau, which assures the consumer that the product purchased from those of its members in good standing will be of a uniformly good quality, at least equal to the requirements of the American Society for Testing Materials, which requirements are also standard with the United States Railway Administration and similar organizations.

The National Malleable Castings Company began the study of the metallurgy of malleable cast iron a great many years ago. The first work of this character was done under the personal supervision of our late president, Mr. Alfred Atmore Pope, under circumstances which made progress possible only for one who was an enthusiast in work of this character. At that time the chemistry of ferrous metals had not been developed to the present extent, the use of the microscope in the investigation of metallurgical problems was entirely unknown, and scientific metallurgy had never been heard from. The problem, therefore, was one very largely of seeking in the dark for the solution of problems dealing with the improvement of the product.

Up to about 1900 most progress of this kind was not well systematized, but there had been evolved methods of procedure which, when carefully followed, yielded in general results satisfactory to the consumers of the period. In the meanwhile also there had been educated a rather limited number of very highly skilled foremen, who, by extremely close application and extraordinary force of memory, were able to interpret very well what they saw going on in the foundries and annealing departments, and to maintain, one might also say, by inspiration a sufficiently accurate control over manufacturing conditions to cope with the requirements of the time.

At approximately this time there developed a much greater general interest among engineers in metalurgical problems, considerable advance was made in the theoretical side of metallurgy, and a number of producers began to attempt the introduction of better methods in their process of manufacture. The writer has been informed that as early as 1893 certain producers of malleable cast iron attempted the operation of a laboratory. Report seems to differ as to just how successful the operation of these early laboratories was and what bearing they had on control of the product which they were supposed to supervise.

At any rate, in 1903 the National Company built at its Indianapolis Works a chemical laboratory for the study and control of its product. It was the writer's privilege to be the first man in charge of this particular laboratory and to be for some years its operating head. When beginning this work we found available published opinions to be quite contradictory—the knowledge of the subject in a rather chaotic condition. Little by little, however, order grew out of confusion, some of the Company's other plants began similar work, and the problems of the industry attracted the attention of university men and others doing research work, until at present at least the broad fundamentals of the industry are absolutely firmly established, and the reason for all the operations undertaken and the circumstances under which these operations may be expected to be successful, are clearly understood.

The pig iron, which is the raw materials of the malleable manufacturer, is all bought under chemical specifications and it is required that all deliveries be accompanied by analyses made by the blast furnace chemists to determine the composition of each individual carload or other unit. These analyses are checked on each carload of iron in the consumer's laboratory, and the metal is finally used on the basis of our own analyses rather than the seller's. If, however, by any chance the foundry's analysis differs from the blast furnace's by more than what is believed to be the manipulative error of analytical methods employed, it is customary to take from the carload of pig iron a second sample and to reanalyze this sample for comparison with the first. In this way it is possible to guard very thoroughly against unknown variations in the composition of metal used as our raw material.

The blast furnace's opportunity for obtaining representative samples is much better than the consumer's. Therefore, their analysis should more accurately represent the average composition of a given carload than ours. Ours is made to preclude the possibility of errors by the blast furnace chemist, of confusion as to whether a given car is actually loaded from a particular cast from which it is believed to have come, and finally as a check on the uniformity of the material composing the carload lot. The analysis of the second sample is made when necessary to guard against analytical errors of our own, and to determine again the possibility of non-uniformity of a given delivery of the raw material.

Malleable iron is in general made in heats varying in size between 6 and 30 tons in different plants. The usual size is, perhaps, 10 to 12 tons. The chemical composition of the iron as cast is of extreme importance as fixing the quality of the product.

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Accordingly the combination of pig irons, scrap, etc., entering the furnace is carefully computed to give an average composition such that after the unavoidable change in chemical composition occurring in melting has taken place, the product will be of the quality desired.

As a check upon the melters, each heat is analyzed before the next heat made under the same conditions is put into the furnace, and from such information the melter is enabled to make any necessary changes in the charges entering his furnaces. In some special cases, notably in the electric furnace operation developed by our Company, the heat is analyzed before it is poured into molds, and an adjustment of chemical composition made when necessary to bring it in line with the desired practice.

The product of the foundry in a malleable plant is not, as is frequently supposed, gray iron. Gray iron is not annealable in any commercial sense, and when an attempt is made to apply this heat treatment to gray iron, a totally valueless commercial product results. The castings as they come from the mold in a malleable foundry are entirely white in fracture, are exceedingly brittle, and also extemely hard—so hard that they cannot be worked with any other cutting tools than abrassive wheels. These castings are then packed in containers, sometimes surrounded by chemically active packing materials, and sometimes not, and heat treated over an extended period. The general commercial practice is, that this entire heat treatment occupies about one week. Within recent years most well conducted malleable foundries have adopted the practice of supervising this heat treatment by means of various types of pyrometers. The most successful of these are the recorder type and maintain a continuous record day and night of the changes of temperature going on. In this way, those in charge of the anneal are enabled to check up the work of the night foreman, and the plant executives are enabled to check the methods of the men responsible for the operation of the annealing departments.

Furthermore, there are cast from each heat a number of test bars of the form and dimensions prescribed by the American Society for Testing Materials, and these are annealed with the acstings. They are then broken as provided by the A. S. T. M. specifications to insure the fact that all the operations have indeed been so conducted as to produce the desired physical properties.

In the case of a product made for the United States Government the Railway Administration and a number of other large consumers, these tests are not only made, but are witnessed by representatives of the inspection departments of the consumer. The later practice, of course, adds nothing to the actual quality of the metal made, since the inspectors have nothing to do with the determinations of what tests the material should stand, but it does insure the consumer against any possibility of fraud on the part of the manufacturer. Just how perfectly it has been possible to conduct the process, I think that, though speaking from memory, I am correct in the statement that in a period of fifteen months the seven malleable foundries operated by the National Malleable Castings Company have had only three rejections by Federal inspectors on their entire output. Inasmuch as the Government material made by these foundries was scattered throughout each of the seven plants, the Federal inspection, while applying only to castings for the Government, practically covered the entire works, and it may, therefore, be said that in this fifteen months' period the entire output of the National Company was of the degree of excellence represented by these statements.

The American Malleable Association maintains a testing department under the supervision of Mr. Enrique Touceda of Albany, New York. This laboratory tests every day bars fom the plants of the firms which are members of the Association. The writer has not taken the trouble to average these results recently, but from general inspection it is quite obvious that the tensile strength of malleable iron as made today approximates 50,000 pounds per square inch, and the elongation is about 10 to 12 per cent as compared with the A. S. T. M. specifications of 45,000 pounds per square inch, combined with an elongation of 7½ per cent.

Any structural material can be used in quite a number of different types of details in which the character of the stresses to which the material is subjected may vary widely. The tensile properties of a material are the most easily determined engineering constants, and are ,therefore, generally used as a measure of the quality of a product. In general, however, relatively few structural details are subjected to purely tensile stress. Rather more common loadings are those cross bending, that is where the structural detail acts as a beam loaded either at the end or at the center, or bearing a distributed load over a greater or less portion of its entire strength.

It has been determined that the modulus of rupture of malleable iron in loadings of this character is approximately 100,000 pounds per square inch, and that the deflections before breaking are very great, so great indeed as to prohibitively distort the member before it actually ceases to carry any load. The material can be loaded to approximately half this intensity without passing its elastic limit..

In pure compression malleable iron possesses properties rather closely akin to those of soft steel, since both these materials in the form of short, thick details will carry almost any amount of load in compression without breaking, though both of them will be much shortened and flattened under the influence of loads of this character.

It is, therefore, difficult to give in a semi-popular manner data as to the behavior of the material under compression. However, in a form of washers and similar details there is no doubt that the ultimate strength approaches 100,000 pounds per square inch. Columns and struts made of any material, while, of course, they are primarily intended to bear compression loads, are always considerably weaker than the compression strength of the material would indicate, inasmuch as they fail, not by crushing, but by springing out of line and then bending. Their behavior under loads depends primarily upon the ratio and length to diameter of the column, and malleable iron, of course, is not usually used for columns of any considerable length.

Tests of details supposed to be representative of rather unfavorable design have shown an ultimate strength of 25,000 or 30,000 pounds per square inch in loadings of this character. In shear, for example, when used as pins, malleable iron has a strength approximately equal to its tensile strength, or perhaps slightly less.

By way of a brief summary ,however, it may not be uninteresting to sum up in the form of general statements a comparison of malleable iron with its two competitors, gray iron and cast steel. The tensile strength of malleable iron is approximately three-quarters that if of soft steel, its elongation is a little less than that of steel, while in comparison with cast iron, the tensile strength is, perhaps, twice as great as the best cast iron, and the latter material has no material elongation in any measurable degree.

In cross bending, gray iron is slightly stronger than either malleable or steel, and steel is slightly stronger than malleable. Malleable iron and steel deflect to the same degree under loads of this character, and both of them distort so much before failure that there is no particular choice between the two materials from this point of view. Gray iron has no deflection under loads of this kind, it is inclined occasionally to break without warning.

In compression malleable iron flows out perhaps a little less rapidly than steel, and not quite to the same degree. Gray iron deflects less rapidly than either of the other products, but crushes into fragments at loads which have not deformed malleable or steel to any material extent for this purpose. Gray iron is valueless under shearing loads, whereas malleable iron has about the same properties as wrought iron, and nearly the same properties as soft steel under loads of this character.

Within the elastic limits the behavior of soft steel and malleable iron, when subjected to twisting, is very much the same. Steel, however, will take a greater twist than malleable iron without completely tearing off, though up to the point where the member is distorted permanently there is practically no choice between the two materials. Gray iron again is too brittle to stand stresses of this character.

Gray iron serves its most useful purpose in the form of columns, where its stiffness prevents the distortion which finally leads to failure by bending up. In such cases as, for instance, the queen posts for car construction, this is not as great an advantage as it seems, for the detail may be broken by an accidental blow and, therefore, be rendered inoperative for the stress which is normally applied to it.

Malleable iron will bend suffiicently to permit of its being fitted against adjoining structural details just as readily as steel. When subjected to such tests as bending double, cold, it is not as malleable as soft steel. Such tests, however, are of course not

ARMOUR

incurred in actual commercial use. It resists shock better and more continuously than either one of its competitors. The most convincing evidence of this fact should probably be its extremely extended use in draft gears, in which the duty of this character is extremely severe. Its microscopic structure is such as to prevent the formation and growth of cracks which cause the failure of a good many structural details of steel under repeated stresses, particularly if these stresses are in different directions.

Malleable iron resists rusting and corrosion to a greater extent than steel ever can, and equals, and sometimes surpasses, cast iron in this respect, more particularly if the cast iron has been carefully cleaned of sand burned to the surface. Furthermore in the nature of the cast, malleable cast iron is entirely free from any internal strains, due to manufacturing operations, since the long continued anneal to which it has been subjected has of necessity relieved any strains of this character. It furthermore has an advantage in structural details, in that it can be cast of lighter sections than steel, and consequently there are a great many illustrations of railway equipment in which the steel casting is much heavier than would be required to sustain the load because of the relatively greater sluggishness of the metal of which it is poured.

Very usually there exists in the minds of consumers of malleable iron, more particularly of those who have used malleable for a great many years, an idea sometimes expressed as, that the strength of malleable iron is all in the skin; sometimes, that the anneal penetrates only a limited amount; sometimes, that malleable is useless in heavy sections——the thought in each case being that there is a limit to the thickness in which malleable iron can be usefully manufactured. Whatever form this idea takes, the conclusion is entirely erroneous. The extreme surface of a test bar of malleable iron is somewhat stronger than the exact center. It is not, however, very materially stronger, possibly 10 per cent or some similar value, and it is quite possible to make malleable castings seveal inches thick in which the central portion possesses all the physical properties required by offiicial requirements.

The annealing of malleable iron is not primarily a process involving the removal of carbon from the surface. Such a removal does unavoidably occur, and occurs also in the annealing of cast steel. The actual change brought about by annealing is the destruction of the combined carbon in the original white iron casting by converting it into a special form of free carbin known as temper carbon. This reaction does not start at any one place in a mass of metal any sooner than in some other place, but goes on uniformly throughout the section. Indeed under most commercial conditions combined carbon persists in the surface a little longer than it does at the center, though this is a point of no commercial significance.

A much more important point in the design of malleable castings than a question of producing sections which are fairly thin, is to so design the casting as to permit the foundry an opportunity of eliminating shrinks, cracks, etc. Malleable iron is less subject to this difficulty than steel, but considerably more subjected to it than gray cast iron. There is an indefinite number of instances in which draftsmen and designers have decided upon shapes and sections not particularly essential to the use of the detail being designed, which present almost insurmountable difficulties in the foundry. Illustrations of this character are, for instance, wheels having light rims, very heavy hubs and an even number of perfectly straight spokes. It is quite easy to produce a design of a wheel of this character in which the foundry problem ceases to be a commercial one and amounts to practically the working of a miracle on the part of the molding department to keep the spokes from cracking or from pulling loose from the hubs. Another difficulty frequently encountered is a part so designed as to have in general very heavy sections, and then at a remote and inaccessible point, an important detail of a very small cross section. Without going deeply into the metallurgy of the process, it may be said that special efforts have to be made in cases of this kind to make it possible to run the small, thin portion at all satisfactory, unless this small portion is located so that it can be brought close to the gate through which the metal is poured into the mold. These and similar items are in addition to the usual problems of the design of cast details such as producing a design which does not require the use of cores to produce unnecessary pockets, designs which can be made in a two part flask without necessitating the use of a three or four part flask, and other similar self-evident matters.

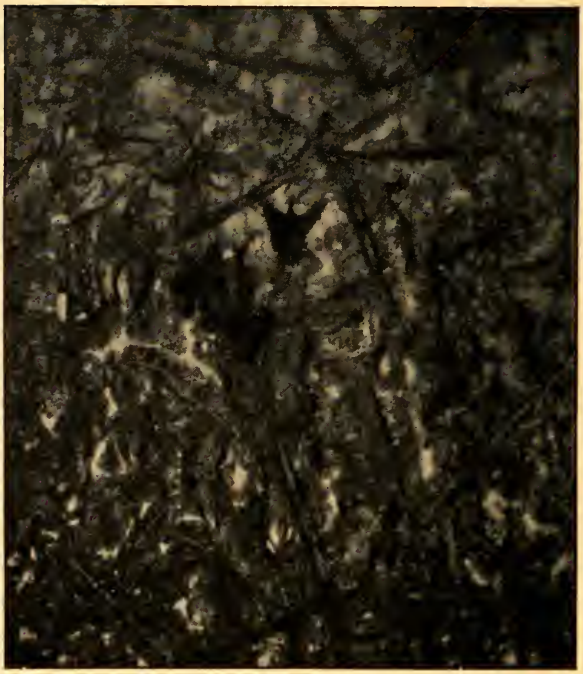

Fig. 1.

No matter what melting method is used, the product of the melting furnace is a white and brittle cast iron. Fig. 1 shows a micro-photograph of such white cast iron. The white ingredient is carbide of iron or cementite. The dark is a solid solution of cementite in iron. The hard iron castings are next packed in any one of a number of packing materials in cast iron boxes in pots, and these are placed in annealing ovens for heat treatment.

After annealing the iron is of black fracture and is tough and malleable. Fractures of the material after annealing are shown in Fig. 2, and a typical micro-phtograph in Fig. 3. The light areas in Fig. 3 are carbon free iron, ferrite, through which are scattered irregular masses of free carbon shown as large black areas in Fig. 3. This carbon is in a special form known as temper carbon aggregations look like spheroidal globules distributed iron in its geometric form. At lower magnifications these temper carbon aggregations look like spherical globules distributed

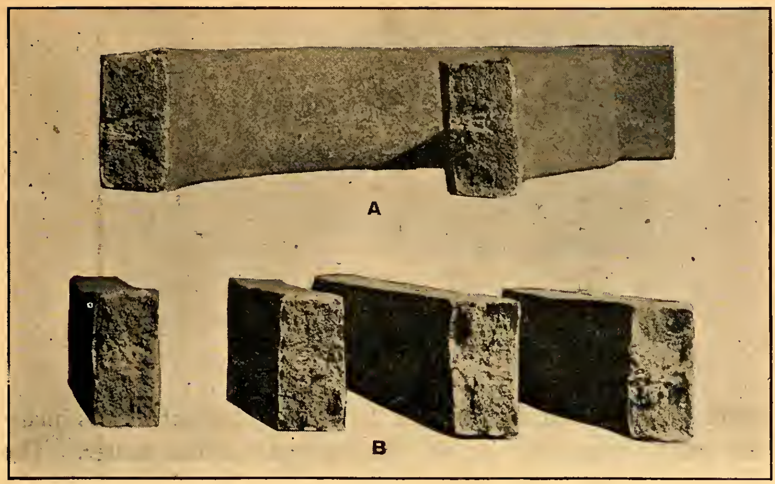

Fig 2.

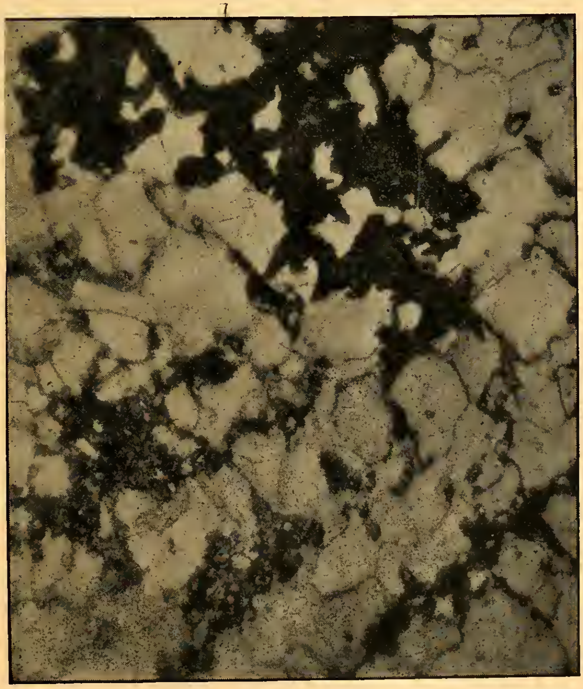

Fig. 3.

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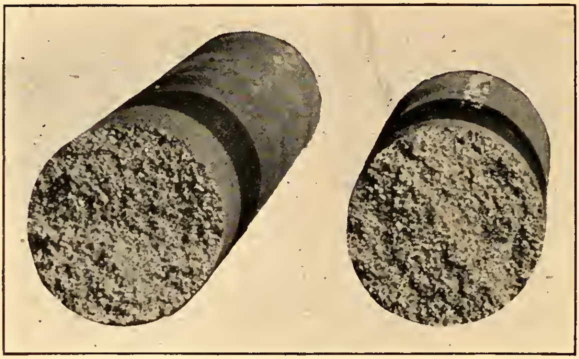

Fig. 4.

more or less uniformly through the casting, present in less quantity near the surface of the casting than at the center. The difference between malleable and gray iron is well shown by the gray iron fractures of Fig. 4 and the micro-photograph, Fig. 5. In the latter the background contains considerable combined

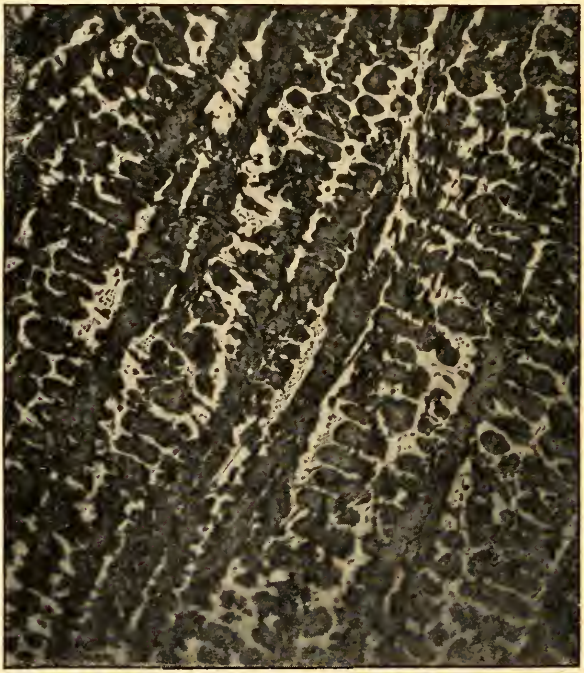

Fig. 5.

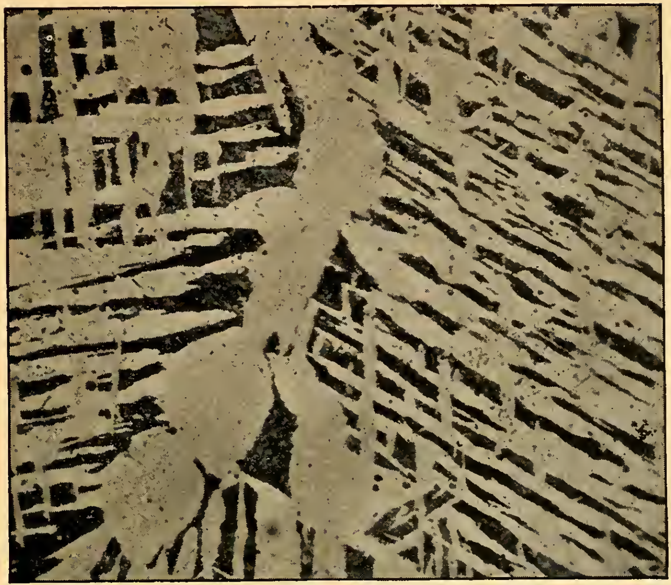

Fig. 6.

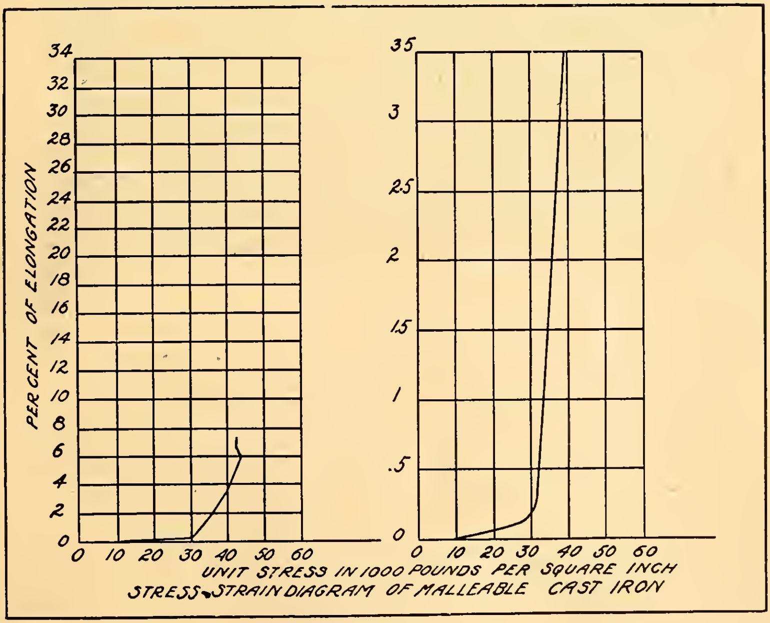
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
PERCENT OF ELONGATION
0 10 20 30 40 50 60
35
3
2.5
2
1.5
1
.5
0
0 10 20 30 40 50 60
UNIT STRESS IN 1000 POUNDS PER SQUARE INCH
STRESS-STRAIN DIAGRAM OF MALLEABLE CAST IRON

Fig. 7.

carbon, as shown by the grayish tint, and the free carbon is present apparently in long black lines which actually are cross sections of approximately flat pieces of graphite.

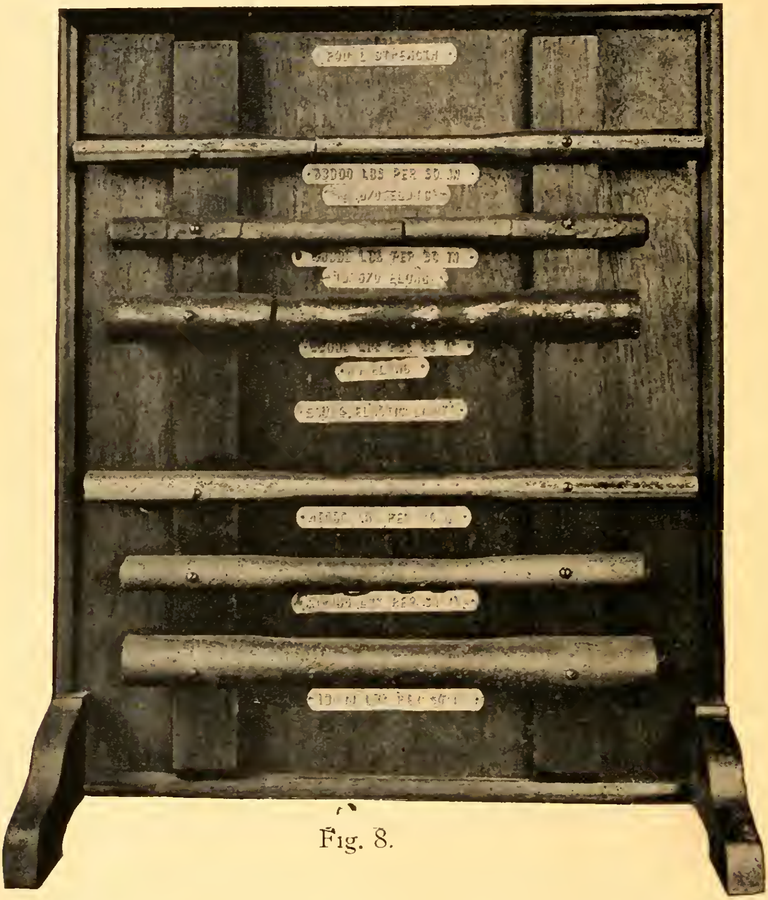

Fig. 8.

Figure 7 is a typical stress-strain diagram of malleable iron, having approximately the properties specified by the A. S. T. M. In Fig. 8 are shown bars giving a comparison of the tensile properties of steel, malleable iron and gray iron. The three upper bars on the exhibit board show bars having the same ultimate strength, the steel bar being somewhat smaller in diameter and the gray iron bar considerably larger than the malleable, thus indicating the relative cross section required to carry the same load with the three different materials. The lower group on the board shows bars having the same yield point, the relationship being much as in the other group, the principal difference being that the steel bar in the lower group is somewhat larger than that in the upper.

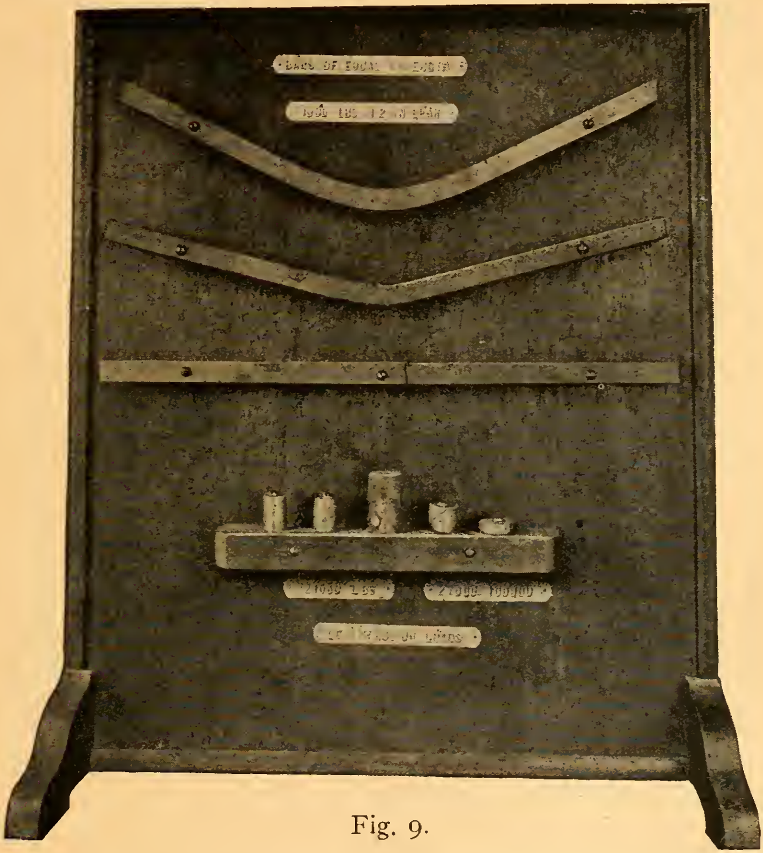

Fig. 9.

Fig. 9 shows a similar comparison of the three materials for cross bending loads. The bars are all of the same thickness, but of different widths. The malleable bar is the widest, the gray iron next and the steel the narrowest. All three of the bars had the same carrying capacity at the center of a 12 inch span. The steel failed by continuing to bend, not by actual rupture, the malleable bar shows a slight tear in the lower surface, and the gray iron bar broke sharply without any deflection.

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The samples on the shelf at the bottom of the exhibit board show the behavior of the material in compression. All of the test specimens were iriginually ½ inch in diameter and 1 inch high. Counting from the left, the first is steel, which has been somewhat compressed under a total load of 21,000 pounds, the next is malleable, compressed somewhat more than the steel, and the sample in the glass tube in the center is a gray iron specimen which has been shattered under the same load. The two samples at the right are malleable iron and steel under heavier loading, to show the additional distortion which occurs.

CALCULATION AND MEASUREMENT OF FLOW OF FLUIDS IN PIPES.

By J. M. Naiman, 21.

Part Two.

FLOW MEASUREMENTS.

GENERAL REMARKS.

Most of the modern methods of measuring flow are indirect methods. The fluid is *not* passed wholly through some mechanism, and the quantity thus discharged measured. Instead, the quantity measured is a pressure difference, which has some definite relation to the quantity of fluid passing through the pipe. The meter then simply registers the discharge corresponding to the pressure difference thus found.

The most common mechanical devices used for obtaining a pressure difference are:

(1) The Pitot Tube,
(2) The Venturi Tube,
(3) The Orifice, and
(4) The Curved Bend.

Briefly, the theory of the pitot tube is that when a moving fluid particle impinges against tube 1 (Fig. 1), it loses its velocity.

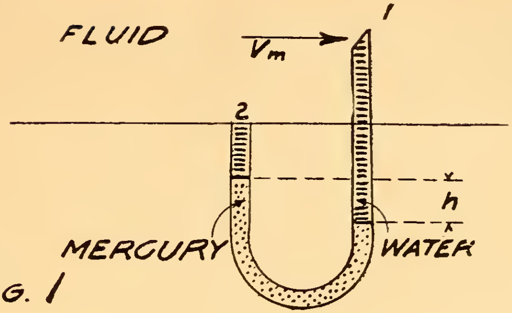

FIG. 1

v_m, and its kinetic energy is changed into pressure potential energy. This factor causes the pressure on the right side of the pitot tube (Fig. 1) to become greater than on the left side, and a difference of mercury or other fluid level is established, as shown in the figure. The actual pressures on each side of U-tube then become: static pressure, say 150 lbs., on the left side and static plus differential pressure, say $150 + 2 = 152$ lbs., on the right

Suppose now that the velocity of the impinging particle is v_m, its density ρ, while the pressure difference registered by the pilot tube is p_d. Then the loss of kinetic energy by each *unit volume* of the impinging particles is $\frac{1}{2} m v_m^2 = \frac{1}{2} \rho v_m^2$, where $m =$ mass of particle $= v \rho = 1 \times \rho = \rho$, since we are dealing with *unit volume*. The pressure potential energy gained by each *unit volume* of the impringing particles is p_d.. From the law of conservation of energy, neglecting friction losses, the loss of kinetic energy should be exactly balanced by the gain of potential energy.

Therefore, $$p_d = \frac{\rho v_m^2}{2} \qquad (11)$$

The density the engineer usually deals with is *weight per unit volume* (D), rather than *mass per unit volume* (ρ). Since the relation between weight $w =$ and mass m is

$$w = mg, \text{ where } g = 32.2 \text{ ft./sec}^2, \text{ and}$$

$$D = \frac{w}{v}, \text{ while}$$

$$\rho = \frac{m}{v},$$

we have,

$$D = \frac{w}{v} = \frac{mg}{v} = \rho g, \text{ or}$$

$$\rho = \frac{D}{g} \qquad (2)$$

Equation (1) may therefore be rewritten thus,

$$\rho_d = \frac{D\, v_m^2}{2g} \text{ (3a), or}$$

$$v_m = \sqrt{2g \frac{\rho_d}{D}} = \sqrt{2g\, H} \qquad (3),$$

where $H = \frac{\rho_d}{D}$, is the height to which the fluid, whose flow is measured, would have to rise to produce a pressure ρ_d. H is commonly known among engineers as *velocity head*. In what follows we shall refer to D simply as *density*.

The pressure difference ρ_d causes a difference in mercury level, h, between the two sides of the pitot tube (Fig. 1), usually water replacing the mercury on the right side for a height, h. This difference in mercury level evidently produces a pressure difference equal to

$$p_m\, gh - p_w\, gh = gh\, (p_m - p \quad Q = gh\, p_d \quad h\, D_d,$$

where ρ_m = volumetric density of mercury,
ρ_w = volumetric density of water,
$\rho_d = p_m - p_w$ = resultant volumetric density.
D_d = resultant density.

The pressure difference produced by the difference in mercury level exactly counterbalances the pressure difference p_d Therefore,

$$\rho_d = h\, D_d \qquad (4),$$

and equation (3) may be rewritten,

$$v_m = \sqrt{2\, g \frac{\rho_d}{D}} = \sqrt{2g\, D_d \frac{h}{D}} = C \sqrt{\frac{h}{D}} \qquad (5),$$

where $C = \sqrt{\frac{2\, g\ D_d}{12}} = \sqrt{\frac{64.4\ (849-62.5)}{12}} = 65$, if

h = *inches* of mercury.

D = density of fluid in pipe measured in lbs./cu. ft.

and V_m = velocity at pitot tube in feet/sec.

An inspection of equation (5) shows that in order to calculate V_m, we must measure not only the difference of mercury level, h, but also the density, D, of the fluid in the pipe. It is for the purpose of emphasizing that it is just as important to measure accurately the density, D, as it is to measure the difference of mercury level, h. that the somewhat detailed devolopment of equation (5) is given. Up to the date of this article, most commercial meters assumed D to be constant, and simply measured h only. Some of them now have pressure and temperature correcting devices for gases and vapors; however, none, to the writer's knowledge, take direct and accurate account of the commonly variable factor, viz., the density, D, of the fluid whose flow is to be measured.

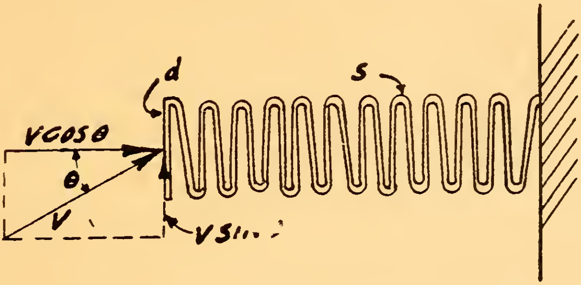

Fig. 2.

In deriving equation (5), nothing has been said about the *direction* of the velocity, V_m, the only thing considered being *magnitude at one point*. To illustrate the importance of the factor of *direction*, let a particle of fluid moving with a velocity, V, strike against a diaphragm, d, (Fig. 2) thereby compressing a spring, S, the direction of V making an angle, θ, with the horizontal.

Also, let perfect elasticity be assumed to make the conditions similar to those existing when the moving fluid particle strikes the fluid in the pitot tube, friction losses being neglected.

If the horizontal and vertical components of V, viz. $v \cos \theta$ and $v \sin \theta$ respectively, are substituted for V, we note that the vertical component, $v \sin \theta$, simply causes the fluid particles to slide

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along the diaphragm with *no pressure whatsoever*. It is the *horizontal* component, $v \cos \theta$, which comprises the spring.

We therefore see that, if the direction of the moving particle impringing against the fluid in the pitot tube is not perpendicular to the face of the tube opening, but makes an angle $\theta + 90$ with the face, as in Fig. 3, the only effective pressure is that produced by the velocity component perpendicular to the opening, i. e., by $V \cos \theta$ (Fig. 3). In general,

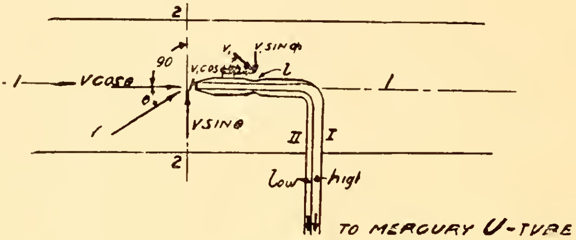

FIG. 3

We are always concerned with the component perpendicular to to the cross section 1—2 of the pipe (Fig. 3), since it is by this cross-sectional area A, that the average velocity, V_a, is to be multiplied to find the quantity of discharge. Thus, if the relation between the average velocity, V_a, on one hand, and the velocity, V_m, where horizontal component, $V_m = v \cos \theta$, is measured by the pitot tube at the center of the pipe, on the other hand, is

$V_a = K\, V_m$ (6), then

the quantity of discharge in cubic feet is.

$$Q = A\, v_a = k\, A\, v = k\, A\, c \sqrt{\frac{h}{D}} \text{ (See 5)}$$

$$= K, \sqrt{\frac{h}{D}} \qquad (7)$$

while the quantity of discharge in pounds is,

$$W = Q\, D = K, D \sqrt{\frac{h}{D}} = K, \sqrt{h\, D} \qquad (8)$$

The velocity at the center of the pipe, V_m is generally assumed to be horizontal and maximum (hence the notation V_m), and the average velocity, V_a, is often taken as 86% of V_m.

If the face of the pitot tube is parallel to the cross-section, 2—2, as in Fig. 3, then no matter at what angle, θ, the velocity, V, approaches the pitot tube, only the desired component, *vcoso,* will be recorded. This is true of the so-called *dynamic* tube, or higher pressure tube, *h,* connected through another tube, *I,* with what would correspond to the *right* side of the U-tube in Fig. 1. However, we are in addition concerned with the *static* pressure, say 150 lbs., exerted upon the fluid. This pressure is transmitted to the *left* side of the U-tube through the so-called *static* or lower pressure tube, *l,* by means of the tube, *II.* For true accuracy, no *dynamic* pressure, i. e., that due to motion, must reach the *static* or left side of the U-tube. Still, when we analyze the effect of the velocity, V, at l (Fig. 3), we note that its component, v, $\sin\theta$ does this very thing, i. e., it introduces dynamic pressure into *II.* The component v, $\cos\theta$ sliding along the tube produces static pressure only.

The factor of *direction* thus introduces considerable error because we know nothing of the value of the angle ϕ, since, as was shown in the author's preceding article on "Flow Calculation," (Armour Engineer, Nov., 1919), the motion usually found in pipes is turbulent. The value of angle ϕ may be almost anything when we have eddy currents. Then again the relation between the average velocity, V_a, and the velocity $v\cos\theta$, (Fig. 3) measured by the pitot tube depends upon the angle θ and in general upon the nature of the motion, of which we lack sufficient information to fix any definite values of K such as 86% in any *special* case. We certainly have no grounds for fixing the value of K as a *general* constant for all fluids.

Another type of pitot tube of commendably simple construction has come to the writer's attention. It simply consists of two parallel tubes with faces beveled at about 70° with the cross-section of the tube. The tubes are screwed into the pipe at right angles with the length of or parallel to the cross-section,2—2, of the pipe (Fig. 4).

Evidently, in this type, the component of velocity recorded by the pitot tube is that *perpendicular* to its face,*F F,* i. e.,

$V = v \ \cos\ (\phi + 20)$, instead of

$V_0 = v \ \cos\phi$, as in previous case.

Now, we are chiefly concerned with the component $v_0 = v\cos\phi$

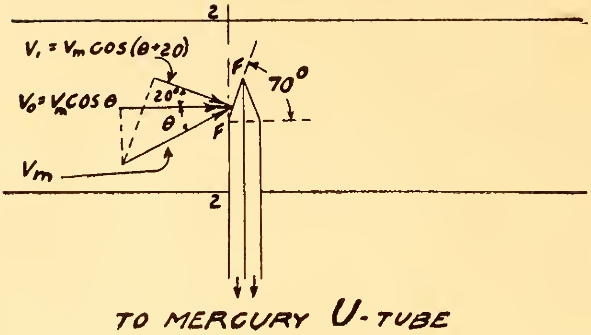

FIG. 4

perpendicular to the cross-section 2—2 of the pipe, and further the average velocity, we want, is, $v_a = .86\, v_m$. If for a moment an ideal condition, where $\phi = o$, were assumed, then the velocity recorded would be, $V_1 = V_0 \cos 20$, and we should have,

$$V_a = .86\, V_m = \text{———}\; V_m \cos 20 = .915\ V. \qquad (6a)$$

Evidently, then, considering the fact that V_1 is the velocity component recorded by the pitot tube, the pitot tube coefficient K, for finding the average velocity, V_a, must be .915 instead of the usual .86. In passing, it is interesting to note that under the same ideal conditions ($\phi = o$), a pitot tube face angle may be so chosen as to make $K = l$; viz.,

$$V_a = .86\, V_m = \frac{.86}{\cos x} V_m \cos x = V_m \cos x = V, \qquad (6b).$$

if $\dfrac{.86}{\cos x} = 1$; i. e., $\cos x = .86$, or

$X = 30.5^\circ$, and $90—X = 59.5^\circ$, instead of 70°.

However, our assumption that $\theta = 0$ does not hold when we are dealing with turbulent motion, and the component of velocity recorded will be $V = v_m \cos (0 + 20)$. Since the average velocity is $v_a = k\, v_m$, its relation to the recorded velocity, v_1, is

$$V_a = K\, V_m = \frac{K}{\cos (\theta + 20)} V_m \cos (\theta + 20) = \frac{K}{\cos (\theta + 20)} V, \ (6\,c)$$

If the angle between v_1 and the horizontal were 0° instead of 20°, as in the case of the pitot tube in Fig. 3, we should have,

$$V_a = \frac{K}{\cos\theta} V_m \cos\theta = K V_m \qquad \text{(See 6)},$$

with no modifications no matter what the value of θ may be. However, in the case of the type of pitot tube shown in Fig. 4, i. e., the *beveled* type, the corrected coefficient, $\frac{K}{\cos(\theta + 20)}$, must be used and is indeterminate, its value ranging from $\frac{K}{\cos\ (70 + 20)} = .915$, when $\theta = 0$, to ———————— = infinity, when $\theta = 70°$. In a turbulent motion, as in our case, the angle θ may be anything.

In addition, we do not know whether the velocity at the center is a maximum or not. Experiment rather tends to show that the velocity at the center is at least *not always* a maximum.* Also, as explained in the author's preceding article, pude reasoning shows that the motions in the upper half and lower half are distinctly different from each other. In general, experiment as well as theory tend to indicate that the maximum velocity may often be at a maximum point away from the center. Considering besides the relative complexity of the turbulent motion affected by the variable temperature conditions and by viscosity, we may repeat that it is hardly justifiable to make any assumptions for special fluid about the value of K for determining the average velocity V_a from the indicated velocity V_m or V. It is certainly hardly permissible to assume one value of K for *all* fluids.

Of the two types of pitot tubes, simplicity of installation is claimed for the *beveled* type, while an argument for the other type is lack of eddy currents due to the tube itself. The horizontal part of the tube in Fig. 3 is supposedly in the direction of flow and therefore does not cause additional disturbances, at least at the face of the tube. Any disturbances due to the part I-II (Fig. 3) of the tube is not supposed to affect conditions at the face of the tube. In the beveled type, the last mentioned disturbances occur right at the face of the tube. The reader is

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* **See article by Bailey, Journal A. S. M. E., Oct., 1916.**

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left to form his own opinion as to the relative merits of the two types.

Sometimes, multi-hole nozzles are used instead of pitot tubes, which in a way may be called single-hole nozzles. For simplicity, we shall assume that the velocities at different points of the cross-section are all in the same direction, viz., perpendicular to the faces of the tube. Let us for a moment imagine that right after the first impact of the moving particles, all the holes are suddenly closed. Then, since the impact pressures produced by the *different* velocities are proportional to the *squares* of the latter ($P = \frac{Dv^2}{2g}$), these pressures must vary from a maximum at the center hole *1* (Fig. 5) to minimums at *3* and 3^1.

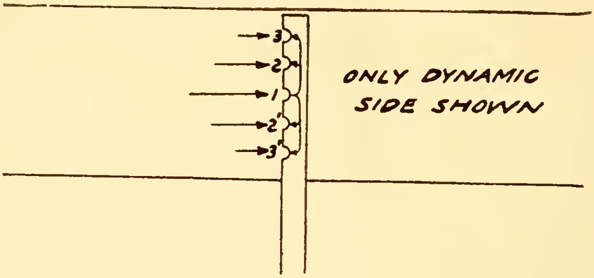

FIG. 5

Therefore, there will be a pressure unbalance which will cause motions from the middle outward, both up and down, until the pressure becomes uniform throughout the tube. Then, the difference of mercury level would register the mean pressure which would correspond to the *mean of the squares* of the velocities throughout the cross-section of the pipe. Thus,

$$Pd = \frac{D}{2g}\left(\frac{v_1^2 + v_2^2 + \ldots\ldots v_n^2}{n}\right) = \frac{D}{2g}\,\frac{\Sigma v^2}{n} \quad (10),$$

provided that the volumes originally affected at the different holes are the same. The average velocity is,

$$v_a = \frac{\Sigma\ v\ \Delta A}{A} \quad (11), \text{ where}$$

ΔA = increment of area, and A = total area of cross-section.

Usually, $v_a^2 \quad \frac{\Sigma v^2}{n}$; e. g., if $v = k_1 - k_2 r^2$, i. e., if v follows the parabolic law as in capillary tubes,

$$v_a^2 = k_1^2 - k_1 k_2 R^2 + \frac{k^2}{4} R^4, \quad \text{while}$$

$$\frac{\Sigma v^2}{n} = \frac{\int v^2 dA}{A} =$$

$$= k^2 - k_1 k_2 R^2 + \frac{k^2}{4} R^4, \text{ as n approaches infinity}$$

Therefore, $v_a = k^1 \sqrt{\frac{\Sigma v^2}{n}} = k^1 v_{a_1}$ (12), where k^1 *is less than* one and v_a^1 = average velocity indicated by tube. However, k^1 is much closer to unity in this case than if only the maximum velocity v_m were measured.

Coming back to actual conditions, if the holes are not closed right after the first impact, but instead are left open, there will be no chance for the different pressures to equalize. Thus, when the pressure established at *1* (Fig. 4) is righer than that, say, at *2*, the equalizing tendency will cause a motion from *1* to *2*. Since, the hole at *2* is open, the motion will not not stop there but will pass through *2* into the pipe. In other words, continuous eddy currents will be produced. This is evident, since the opposing pressure corresponding to the fluid impringing at *2* is smaller than the actuating pressure of *1*. There will thus be a general weakening of the effective pressure produced by the kinetic energy, because some of the latter is changed right back from pressure potential energy to kinetic energy. Therefore, only a part of the original kinetic energy is utilized in producing pitot tube pressure. Clogging up of some of the holes decreases the eddy currents through the nozzle and as a result increases the effective tube pressure. However, it would seem rather peculiar to replace a pitot tube by a multi-nozzle tube and then hope that the holes will be clogged up, and that thereby the effective pressure will be increased.

As a whole, neither the pitot tube nor the multi-hole nozzle seems to make a dependable flow metering device, especially when we note that we have considered only the difficulties arising from the horizontal and vertical velocity components, and have neglected the velocity component perpendicular to the length of the pipe. When we try to analyze this actual motion in three dimensions, the task becomes still more difficult.

The venturi tube and the orifice are similar in that both tend to produce a change in velocity with a corresponding change in pressure. In the venturi tube, the *reduction* of the cross-sectional area at the so-called throat from that at the junction with the pipe, through which the fluid flows, causes the velocity to increase in proportion to the decrease in area. This must be so inorder to maintain the *continuity* of flow, i. e., in order that the mass of fluid entering the venturi tube at its junction with the pipe should be the same as that entering the throat. Thus,

$$vA = Va \quad (13),$$

where v, a and V, A represent the *small* velocity and area and the *large* velocity and area, respectively.

Assuming *stream line motion,* the total energy along a stream line must not change, according to the law of conservation of energy (Bernoulli's theorem). Now, since along any stream line, the kinetic energy *increases* as the throat is approached, the pressure potential eneregy must *decrease.* Therefore, the pressure must drop at the threoat. The difference of pressure, along any stream line, between the point at the entrance to the venturi tube and that at the threoat, is related to the velocity along the same stream line at the throat, in the following manner:

$$v = K\sqrt{2gH}^{*1} \qquad (14),$$

where, as before, $H = \dfrac{Pd}{D}$ (see eq. 3),

Pd = pressure difference,
D = densiy.

K is a constant of the stream line depending on the relative po-

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[*1] See any text book on Hydraulics.

sition of the latter. The same expression with a modified K is commonly used for finding the average velocity, va. The reasoning for the orifice, which similiary to the venturi tube, contracts the cross-sectio nthrough which the fluid flows, is the same as that for the venturi tube, with a different value for K.

The first objection, that the reader would probably raise, is that the motion through either the venturi tube or the orifice is not a stream line motion, but is still turbulent as in the case of the pitot tube. Bernoulli's theorem would then have to be modified to take care of kinetic energy of rotation, the latter depending upon the *angular velocity,* which we know nothing about.

Again, the pressure throughout the cross-section is not the same but varies from point to point*[2]. Since the pressure usually measured is that at one point of the cross-section, we must know the relation between the pressure measured and the average pressure of the cross-section. Or we must know the exact relation between the pressure difference recorded, and the *average* velocity.

The objectionable feature of velocity direction, inherent in pitot tube measurements, is somewhat reduced when either the venturi tube or orifice is used, since only *static pressures* are measured. Of the latter two devices, the orifice is usually considered preferable for economical reasons as well as for convenience of installation; besides, the annular ring of the orifice seem to act as a temporary stop for the turbulent motion in the outer parts of the cross-section of the pipe, thus somewhat readjusting and breaking up the turbulent motion. But it does not do it quite enough, and there is always turbulent motion left, with the result that a different coefficient has to be found for different sets of conditions even when we are dealing with the same pipe and the same fluid.

To date, the orifice has given the best practical results, as a mechanical metering device. However, a new mechanical metering device was recently invented, and the latent experiments seem to indicate that it may eventually replace the orifice for accurate measurements. The device referred to is the *curved bend,* a full description of which together with experimental results will be given in a separate article.

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*[2] See auhtor's "Flow Calculations," Armour Engineer, Nov., 1919.

The problem of commercial metering can thus be seen to consist of two parts involving two distinct devices:

(1) The *mechanical device*, for securing a pressure difference, affecting, say, a mercury level, and (2) the *registering device*, for automatically indicating, recording and integrateing the mercury level, in terms of the volume or weight of the fluid passed through the pipe.

Since it was shown that the expressions for volume and weight discharged are, respectively,

$$Q = K, \sqrt{\frac{h}{D}}, \text{ (see eq. 7)}$$

$$\text{and } W = K, \sqrt{hD}, \text{ (see eq. 8)}$$

the registering device must evidently automatically take care of two variable quantities:

(a) *Difference of pressure*, represented by the difference in mercury lever h, and *Density* of the fluid, D.

Recording devices and the mechanical device, known as the *curved bend*, will be taken up by the writer in later issues of this publication.

(To be Continued.)

LE RHONE AIRCRAFT ENGINE TESTING.

By E. C. Cook, '20

The Le Rhone airplane engine, one of the most successful types of airplane engines developed by the French engine manufacturers up to the end of 1918, was standardized by the U. S. Government as one of the engines to be produced as part of the large U. S. aircraft program and the plans were for the manufacture of these engines at the rate of 30 per day. This work was undertaken by a large Eastern manufacturing concern well equipped to do practically all of the work from making the castings and forgings to the finished product within their own control. A few parts only were fabricated by outside firms.

The model adopted was the 105 mm. bore x 140 mm. stroke, 80 horsepower, 9 cylinder engine which is rated at 1200 R. P. M. and, like the Gnome engine, produced by the same company in France, is of the rotary cylinder type. The large hollow crankshaft has one crank and is fastened rigidly to the mounting plate at the rear of the engine. At the extreme rear of the crankshaft is fitted the bloc-tube carburetor or mixing valve which feeds the gasoline vapor through the shaft into the interior of the crankcase. From there the gas reaches the tops of the cylinders through radial manifolds. The nine cylinders are arranged radially in one plane about the single crankthrow to which are fastened the nine connecting rods. . Fig 1 shows the arrangement of three of the rod feet in the thrust-block together with the pistons and half of the thrust-block. The nine rods consist of three each of the rods shown in the photograph. The cam unit is shown below.

The cylinders, crankcase, pistons and connecting rods revolve about, and are supported by, the crankshaft. The running balance of this engine is practically perfect and it acts as its own flywheel.

The steel cylinders are each machined from a heavy forging and have air cooling fins and the valve pockets integral with the cylinder proper. These cylinders are screwed and locked into the steel crankcase, which also is machined from a forging. The steel nose plate for the propeller mounting is bolted directly to the front of the crankcase.

The valve system consists of two valves, an inlet and an exhaust, in each cylinder head and operated by a single push-rod. Two five lobed cams in the crankcase rotate at 9/10 engine speed and operate the push-rods through rocker arms. Ignition is by a single magneto running at 2¼ engine speed.

Each engine, before accepted by the Government, must be given a preliminary run, inspection and acceptance test of horsepower.

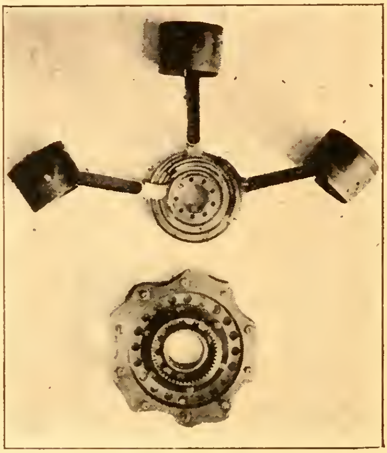

Fig. 1.
Above—Set of Three Pistons and Rods. Below—Cam Assembly.

The preliminary run consisted of a 3 hour duration test at part throttle but stoppages due to sparkplug trouble, which were somewhat frequent, did not invalidate the test.

After the preliminary run the engine was dismantled and inspected. The cylinders and pistons were washed in a hot soda solution to loosen the carbon, while the other parts were again closely inspected and any part found faulty during these two inspections was replaced. In the event that a major part such as cylinder, piston, crankcase, etc., required replacement the engine was again given a preliminary run of one and one-half hours and the faulty part inspected. Minor parts could be replaced without additional test.

Following the re-assembly the engine was given a test of 20 minutes at full power. The requirements called for 80 H. P. net at 1200 R. P. M. maintained during the 20 min. test. After a satisfactory test the engine was acecpted and crated for shipment without further cleaning.

From each 100 engines one engine was to be chosen at random and submitted to a 50-hour series of tests consisting of ten 5-hour runs.

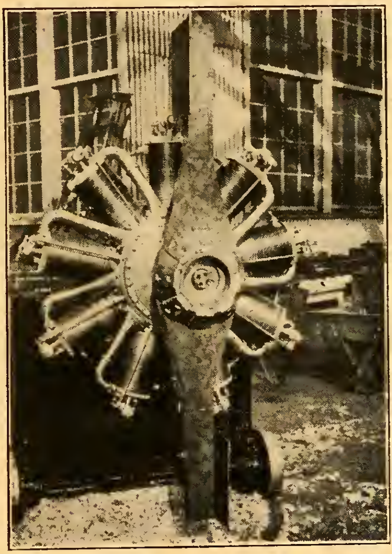

Fig. 2. Engine Showing Starting Clutch.

Second class engines were assembled from non-interchangeable parts and marked, "Not to Be Flown." These were given a similar test to that of the production engines. Third class engines were assembled of defective parts and marked "Not to Be Run." The latter class were for instruction purposes and constituted a useful outlet for parts rejected in manufacture.

Owing to the unusual type of engine and its requirements, the orthodox methods of automobile engine testing by means of an absorbtion dynamometer, either electric, friction, or water types, could not well be used. The cooling of the cylinders when

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the engine is not traveling forward, as in an airplane, presents the main difficulty in testing this type of engine. The snail methed as used by the French gives satisfactory cooling and consists essentially of a centrifugal blower and stack. A "club" or paddle took the place of the propellor and the engine was mounted upon a test craddle which in turn was supported by heavy ball bearings on the test stand. The test stand was on wheels and guides on the floor permitted it to be placed with the engine and "club" inside of the "snail." The "club" and engine revolving at 1200 R. P. M. forced the air up through the stack to get rid of the oil-laden exhaust gases. The air entering the snail in front and in back of the engine gave sufficient cooling for the tests.

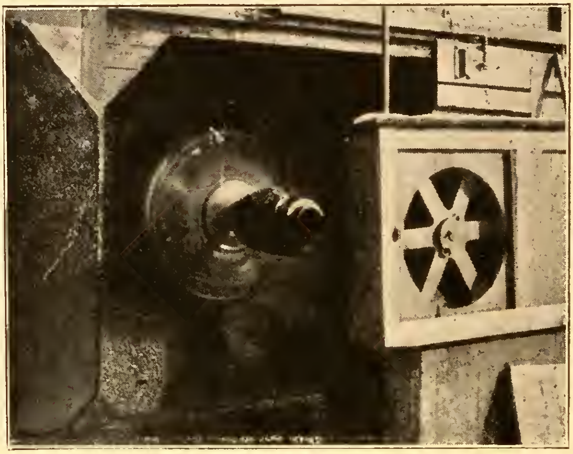

Fig. 3. Engine Running in Snail.

A 3 horsepower motor outside of the snail was geared down to a cone friction clutch which, by means of a set of levers from inside of the building, could be engaged with a wooden faced cone on the hub of the "club" for starting the engines. The guides on the floor and a latch engaging the rear axle of the test stand gave sufficient alignment for this starting mechanism.

Torque reaction was measured by means of a graduated balance arm mounted on the test cradle with a movable weight of 126 lbs. 3 oz., hung from it.

An early attempt to record the torque by employing an oil-filled cylinder and plunger connected with a recording pressure gauge did not give satisfaction due to the sudden shocks upon the system when the engine running was irregular. The oil cylinder axis was perpendicular to the engine axis and 31 33/64 inches below it. Although the pressure readings, unless regularly checked, were liable to be in error, the records of the test runs showed graphically the nature of the run and the relative variations in torque during the test.

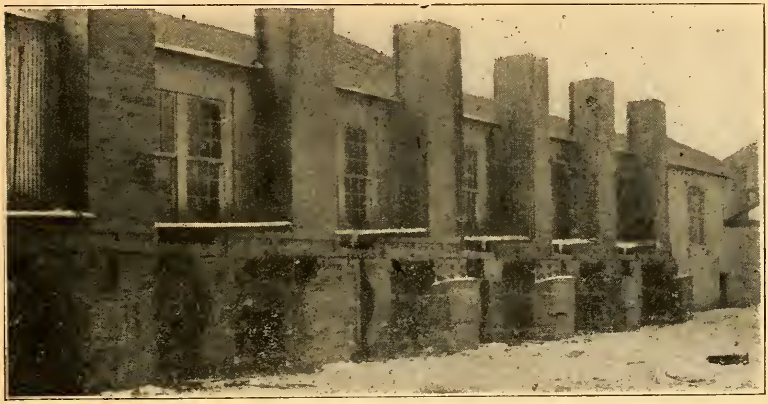

Fig. 4. Row of Signals.

The revolutions per minute of the engine were obtained by means of a revolution counter and a system of lights flashed at each snail stand every five minutes for the 20 minute test and every ten minutes for the three hour test. A preliminary warning light flashed before the time light and these were all operated by a master electrical clock.

A tachometer in connection with the revolution counter gave the approximate instantaneous speed of rotation.

As first constructed, the clubs required more than 80 H. P. at 1200 R. P .M. and the blade area was reduced by removing 5 millimeters of each trip which then gave 80 H.P. net at the above mentioned speed.

The engine itself had a windage loss due to its own wind resistance of revolution, and the actual reaction H. P. is the sum of this windage H. P. and the net H. P. delivered to the club. Since the H. P. measured by the torque arm is the gross or reaction H. P., it is necessary to deduct the windage loss. British tests on this model of engine showed the windage loss to be about 9.38 H. P. at 1200 R. P. M. Thus the minimum gross H. P. required for acceptance was 89.38 H. P. at 1200 R. P. M.

The windage loss of the engine obeys the same laws as those for the club and, knowing the windage loss for different speeds and measuring the gross horsepower by means of the torque arm, a curve of the net horsepower may be obtained. Corrections in all cases were made for variations in air density. A recording thermometer and barometer were used for this purpose and all readings were corrected to 760 mm. and 15 degrees Centigrade.

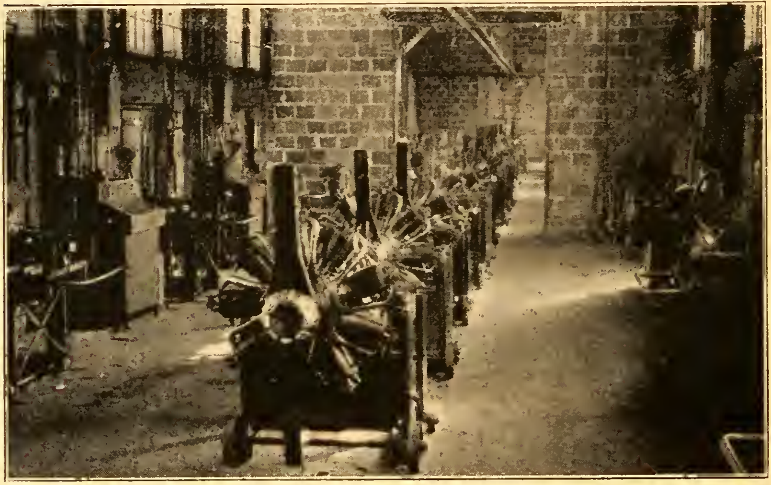

Fig. 5. Le Rhone Engines Mounted Upon Test Stands.

The clubs were accurately constructed and then checked for horsepower. In this they were found to be in very close agreement—so much so that a calibration curve for the net horsepower against R. P. M. was made and used for similar clubs.

The net horsepower was read directly from this curve and did not then require correction for air density. Within the limits of air density variation due to atmosphereic conditions experienced, engine horsepower and club horsepower were considered to obey the same law of variation, i. e., to vary directly as the air density.

The oil and gasoline supply to the engines was from a 5-gallon sheet iron gasoline tank and a small oil tank made of 4″ glass tubing ,each being mounted at every snail. Supply leads furnished the fuel and oil to these stands from large capacity tanks at some distance from the test buildings. The gauge glasses for each tank were calibrated directly in pounds. The fuel and oil were of fairly constant density and any change in the density of either fuel or oil caused the graduated scale for the gauge glass to be changed. The gasoline used was of 65 to 68 degrees Baumè density. Castor oil was first used as a lubricant and when the government demanded its use only on flying fields, a heavy steam cylinder oil, 600-W, was used satisfactorily. Several other commercial brands of mineral oil were found to behave well in the engine.

For the connections for the oil between the tank and oil pump and for the gasoline between the tank and regulator Titeflex metallic flexible hose was used and found to be satisfactory. No rubber tubing then available and tried was able to last for any considerable length of time when used as the gasoline line.

The 50-hour test enabled the ascertaining of the merits of different manufacturing changes such as piston clearances, etc.

On one occasion one engine was permitted to run until it stopped of its own accord. After 61 hours the steel lining of the snail worked loose on account of the vibration and it was struck by the club, forcing the engine to stop.

Along with the three-hour preliminary tests, spark-plug and magneto comparisons were carried out. Special plugs or magnetos would be substituted for the standard equipment and a record kept of their performances.

Tests for maximum power with a torque arm showed that under good conditions a brake mean effective pressure of 93-94 lbs. per square inch based upon the gross horsepower could be maintained while a few exceptional engines showed greater possibilities.

At the time that the available source of castor oil seemed inadequate it became imperative that some other kind of oil be found to take its place. Consequently a series of special oil tests of five

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hours' duration were made with the most likely mineral oils. Carbonization as well as power was of vital importance in the selection of the oils and several brands proved suitable during these tests.

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By A. E. Fisher, Librarian.
(Armour Institute of Technology Library.)

To those outside library circles, the classification of books often seems most intricate. If we consider it from the standpoint of a dictionary definition of the word, "the act of grouping together those things which have certain characters in common," the purpose will perhaps be clearer. Mr. C. A. Cutter defines book classification as "the grouping of books written on the same or similar subjects." It is done to the end that "economy and efficiency in the use of books may be secured."

All systems of classifification are of necessity more or less arbitrary. In no two libraries will one find exactly the same classification for all books, because convenience has become the criterion in the modern library. For example, a book dealing with the question of Hamlet's sanity would in a public library be placed with the books of Shakespeare, while in a medical library it would probably class with those on insanity. Furthermore, authors are not considering the librarians when writing books. Many times a book will deal with several subjects and might have several places, thus complicating the work of the classifier.

The Dewey Decimal System is the one in use at the Armour Institute of Technology. As the name implies, it is based upon "Arabic numerals used dicimally and supplemented occasionally by letters." While far from perfect, it combined the qualities of simplicity and flexibility. Perhaps its greatest claim is that it has stood the test of use. The following is a brief summary of it, with the classes most interesting to an engineer given more fully:

- 000 General Works.
- 100 Philosophy.
- 200 Religion.
- 300 Sociology.
- 400 Philology.
- 500 Natural Science.
  - 510 Mathematics.
  - 520 Astronomy.
  - 530 Physics.
  - 540 Chemistry.
- 600 Useful Arts.

  - 620 Engineering.
    - 621 Mechanical.
    - 622 Mining.
    - 623 Military & Naval.
    - 624 Bridge & Roof.
    - 625 Road & Railroad.
    - 626 Canal.
    - 627 River & Harbor.
    - 628 Sanitary.
  - 660 Chemical Technology.
    - 661 Chemicals.
    - 662 Explosives.
    - 663 Beverages.
    - 664 Foods.
    - 665 Lights.
    - 666 Ceramics.
    - 667 Bleaching.
    - 669 Metallurgy.
  - 680 Mechanic Trades.
  - 690 Building.
    - 691 Materials.
    - 693 Masonry.
    - 696 Plumbing.
    - 697 Heating & Ventillating.
- 700 Fine Arts.
  - 720 Architecture.
- 800 Literature.
- 900 History.

This summary illustrates the principles of the Dewey System, namely, all subjects divided into ten general groups, each of these ten divided into ten, and each one again divided into ten. Following this general rule, every classification number has at least *three* figures. If a further division is desired, a decimal point and a number may be added. Thus, 600 is Useful Arts, 620 Engineering, 621 Mechanical Engineering, and 621.1 Steam Engineering. A concrete example of this would be the classification of W. R. King's book on "Steam Enginering." When this book came into the Library for classification, an examination of the large headings placed it unquestionably under Useful Arts, 600.

This was far too general; therefore, it was placed under the second heading, Engineering, 620. This also covered too large a field. Of the divisions under 620, our book fell logically under 621, Mechanical Engineering. Even this was still too broad, because Steam Engineering is only one part of Mechanical Engineering. Thus, the first division under 621 is Steam Engineering, 621.1. So the book was classed 621.1.

Each numerical division is seen to have a logical relation to the class above, to the class below and so to the entire system.

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THE IDEAL MUST BE ATTAINABLE.

We are all familiar with Emerson's saying, "Hitch your wagon to a star." In opposition to this maxim another great man, Cardinal Richelieu, said, "I accomplished much because I set strict limits to what I undertook." Are the two ideals really at conflict with each other? I do not think so. Emerson referred to the development of character and the growth of personality. In regard to morality, only the highest ideal is acceptable. The life and teachings of Christ are before all mankind as the star guiding human conscience. In the practical affairs of life, however, it is well to remember that the ideal we follow must be attainable.

These reflections occurred to me while reading the December number of *The Intercollegiate,* a publication devoted to the work of the Young Men's Christian Associations in the universities, colleges, and schools. Two articles in that number seemed to be of especial importance. One, by Henry Churchill King, is on "The Necessity of American Students Having the International Mind.". The other article is entitled "What Is the Interchurch World Movement?" The writers of both articles emphasize the thought that the present time of reconstruction and international understanding requires a special "personal sharing of the great intellectual and spiritual achievements of the race." Mr. King's plea is that American students especially should acquire the *international mind* because of the responsibility of the United States to carry to successful solution the great problems which the war has brought about in the relations of nations. Very eloquently and cogently he mentions excellent reasons why this should be so. The scientific spirit, the historical spirit, the philosophical mind, aesthetic appreciation, and social consciousness all require that the American student should rise above parochial and narrow limitations. Truly "isolation means narrowness and selfishness." Science, art, and commerce are all international. He who wishes to succeed in any one of these must certainly have a broad outlook upon many climes and many nations, with a background of historical appreciation.

In like manner, the Interchurch World Movement emphasizes internationalism. Its aim is "to recruit men and women to undertake and achieve the great world task of a united church." This movement certainly demands the international mind as well as the international heart of its devotees, calling for highest culture and constructive talent. It is an ideal worthy of the highest effort.

A close and thorough examination, however, of actual conditions, and especially also of the limitations of international and individual ability and power, urges the undersigned to utter a word of caution. All human achievement is definite and must be grounded on well defined and circumscribed conditions. Nothing is easier than to follow the Will o' the Wisp of high-sounding phrases and sentiments. Let us not lose the sure ground under our feet. As the advice of these writers is given to American college students, we must not forget that these are yet in a period of development and consequent immaturity of thought and experience. The adoption of ideals of a certain character may be premature in the life of many of these young men and women. Every day we meet people who are perfectly willing to do something for humanity at large while they are neglectful in the most elementary courtesy or helplessness to those nearest to them. The members of the family, the fellow students of our college, the citizens of our town, and our nation, all have first claim on us—on our sympathy, on our thought, and on our work. Let not pretentions, even if they be inspired by lofty ideals, outrun our ability! No success attaches itself to ambition which is not completely sustained by ability of performance. The word of caution which I should like to add is the demand that *the ideal must be attainable.* Joseph Conrad, in his novel "Under Western Eyes," writes the following paragraph:

> "History, not Theory;
> Patriotism, not Internationalism;
> Evolution, not Revolution;
> Construction, not Distruction;
> Unity, not Disruption."

Patriotism precedes internationalism, just as the study of our own language precedes the study of any foreign language. The duty of earning our own living precedes that of helping others to earn their's. The duty of educating our tastes, of increasing our powers of appreciation, of developing good judgment and good conduct must precede our attempts to bring others to a realization of the meaning of life. Self-expression is mere commotion when there is nothing to express. Before attempting to know all things, let us try to master *one*. Patriotism is a high ideal, absorbing all the powers of a strong mind and heart. With all the fire of youth and the ardor of undiminished strength, let us hold to the thought: My work, my home, my country, first of all. As we swear allegiance to *one* woman, *one* God, and *one* country, we are in a sense narrowing ourselves to definite duties, and a well defined direction of our life. The gigantic task of expanding our sympathies, our understanding and insight to an international mind, to interchurch, or any kind of international movement, may be undertaken by the few only who have arrived at maturity of judgment and at a very extended experience of human affairs. Youth mounts up with "wings as eagles," manhood "runs and is not weary," wisdom "walks, but does not faint." In the practical affairs of life, it is best to walk first, then to run, and last of all to "mount up with wings as eagles."

This word of caution, I hope, will be rightly understood. No criticism is intended of the articles mentioned, but a warning may not be inopportune to go slowly and to define carefully what we mean by the "international mind" as well as by "world movement." The great necessity of American students is a clear understanding of the rights and duties of an American citizen, of the problems and obligations which patriotism imposes, and of the sacred task of keeping the home fires burning brightly. To the youthful enthusiasm, which rises on "wings as eagles," let us say once more, in the practical affairs of life the *ideal must be attainable.*

LOUIS C. MONIN.

OPPORTUNITIES FOR THE YOUNG MAN IN CORPORATIONS.

By JAS. B. HARGEY, E. E., '09.
Vice-President Continental Gas & Electric Corporation.

If we may consider the most desirable training for this business, I would say it should start with an engineering course in some good institution. However, after graduation, instead of taking the short-sighted view, which most students do, and endeavoring to get into pure engineering work in some company, I believe that our candidate should forget, as far as possible, the fact that he he has an engineering education, and start in just as he would if he came from high school or grammar school, shoulder to shoulder with the young man he finds in the business, and that this start should be made, perferably in the commercial end of the business, with the idea that what he proposes to do

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is to reach the head of the institution through the most direct and practical route of helping to build up and carry on the commercial features of the business, depending on his engineering education only for the assistance which he will find that it will be to him from day to day, as he goes along. Any young man entering the business should devote a good deal of his leisure time to the consideration of a great many things outside of his regular work, not to the extent of slighting the regular work, but to the well balanced man the combination is entirely consistent.

Three important subjects for study loom up in the mind of the writer. The organization of the business, involving a study of its corporate existence and powers, and also its arrangements in departments. The financial structure upon which it is based, and the best and most economical methods of financing such companies, with consideration of all the difficulties; and finally, a very comprehensive view of the possibilities in the way of extending business.

One of the great dangers of a young man in business, particularly if he is especially bright and well prepared, is that he is likely to be too ambitious and want to go ahead faster than his commercial experience and the general situation of that particular business will permit, with the result that he changes frequently and finally becomes a rolling stone. That is something every young man should guard against. Remember that it is where you will be twenty-five years from the time of starting, and not at the end of the first five years, that should concern you. In my business experience two mottoes have forced themselves upon my attention and, while there are many others, I believe that these two are worthy of the very careful consideration of every striving young man. One of these, which comes from the Scriptures, is as follows: "Neglect not the gift which is in thee." Nearly everyone has talent along some direction, and that talent should always be cultivated, as such cultivation means the development of individuality and force of character. The second one, called to my attention by a man at the head of a correspondence school, is as follows: "The reason most men do not accomplish more is because they do not attempt more."

This is exceedingly true. A man to be a success must have initiative. He must not shirk the responsibility, and sometimes it is a very great responsibility, of putting his ideas into creation. Most men have ideas, and while some men become distinguished by carrying out the ideas of others, to the majority of us, no man is a greater bore than one who is constantly suggesting more or less wild ideas; apparently expecting to have them taken up and worked out, but making no move himself to do so.

A study of human efficiency is a study to which we should all give attention. The best men are far from 100% efficient. Good judgment in arranging one's habits and methods of living is fundamental in this, as health has a great deal to do with it, and this calls attention to the importance of caring for the physical health and strength. In the competition of the present day, no man short of a phenomenon will get very far who has not the physical strength and endurance to support his ambition and mental activity.

In the great industrial organizations which mark the present period's development, it is especially essential that every man should be a good soldier. All of us in our business careers have fallen in with the fellow who has no capacity for working in an organization and it frequently happens that this fellow is particularly brilliant in many ways. But nothing can be accomplished without organization, and organization means that a great mass of men must work under leaders in the industrial and commercial line, just as in the military line, and you can therefore put it down as a rule as between the very brilliant man who cannot work in an organization with his fellows, and the man of mediocre ability, who is a good soldier in the true sense of the word, there is no question as to the ultimate success.

The latter will win out every time, and the organization will profit under his work where it suffers under the disorganizing influence of the other man. You will frequently hear men blustering about their independence and telling what they will not do for any man. As a general rule this is a mark of the uneducated and unthinking. In the country in which we live a man is only subject to his own will so long as he obeys laws necessary to the best interests of society, and if he places himself in an organization, it is simply because he has himself in control and because his will and brain dominate the physical man, because he realizes the necessity of organization and that without it and the discipline which is essential to it, nothing can be accomplished.

FRESHMAN, LET'S GO!

Just as the eminent engineer, Dr. Charles Proteus Steinmetz, intimated his addres before a large Armour audience last October, Engineers do not participate as actively or as prominently in public affairs as they should, and both the public welfare and their own individual advancement would be promoted if this condition could be rectified."

While editorials and articles regarding this subject are being published almost daily, and while some of the great institutions of learning are planning and answering various plans for changing their respective curiculums to counteract that tendency, let us give our udivided attention to condition in our own institute.

As it is in the engineering profession and public affairs, so it is in our institute. The Armour student body is our public; the institute activities our public affairs. The leaders are those who have been most active in their respective organizations and societies.

Their ability for effective collective effort has been developed to a large extent by their activities in the institute and in similar organizations.

"The engineer is one of the instruments provided by the institute for the student body, and it affords an opportunity for the prospective individual engineer to contribute for publication something of interest and value for his experience, in exchange for the ideas which he receives from other contributors."

The present and future of the institute, its various societies, the Cycle and the Engineer are contingent upon the degree of activity possessed by the individuals to constitute the student body.

FRESHMAN!

SET THE PACE!

JOIN YOUR RESPECTIVE ENGINEERING SOCIETY! SUBSCRIBE AND CONTRIBUTE MATERIAL TO THE CYCLE! LIKEWISE THE ENGINEER! AND ACT AT ONCE!

Walter M. Seyferlich.

Assemblies

TECHNICAL EDUCATION

On October 31st the students and faculty of Armour Institute of Technology had the privilege of listening to a most interesting address by Dr. Charles P. Steinmetz, Consulting Engineer to the General Electric Co., and who stands at the head of his profession of engineering. He spoke on the subject of "Technical Education."

He began his address with a brief comment upon the rather recent origin of Technical Education and its development due to the rapid advancement of engineering during the last generation.

Technical institutions originated in two manners; either as wholly technical institutions of learning, or as classical institutions and universities. In the latter engineering courses were established in addition to the classical and scientific courses which they had. Then, engineering was based on existing humanistic courses by adding instructors and assistants, using the same general education of the old world in engineering. Thus, institutions were created to take care of the demand for engineers. Very frequently, the courses were designed by dropping everything except what was essential and necessary, or appeared to be, for the profession of engineering. In mathematics it was found very greatly reduced, because, especially in those days, so many engineers had been quite successful in mathematics. It was absurd to assume that the engineer did not need mathematics. Next started the controversy between the strictly professional training and the broad engineering educatnon; on one side omitting literature, omitting English ,omitting general science, and general humanistic subjects, and training purely in engineering. On the other hand, the training in general education embodies science, languages, literature, and leads up to the engineering education. Both sides had their defenders, and we all know that the final conclusion and the final decision was more or less of a compromise towards the side of the college or university, and not the mere training school. Thus, experience has shown the value, to the engineer, of a broad general education. This is due, to a considerable extent, to the close co-operation that was established in other days between the educational institutions and the industries. Industries needed the college trained young men as engineers, and thereby gave precedence in the industrial world to college trained young men. In some other nations like England, however, there has been rather an antagonism between industry and educational institutions.

Dr. Steinmetz then brought out the fact that many leaders of industry are self-made men who consider that the college engineering student is not as practical as he should be and therefore they have not employed students. Others, such as the General Electric Company and the Westinghouse Company, called on the technical institutions for their leaders in the engineering field, and engineering departments, and took an active interest in the curriculum, in courses of study offered, and offered to the instructors and professors chances to enter the industry and become familiar wit hthe practical side, in short, to establish the greatest corporations that have existed with the industrial world getting the fullest benefit of technical institutions.

Most institutions now have a general educational course dealing with all subjects, and do not attempt to teach the students all of the details of all of the machinery that is being used. Then, the student, coming to the factory, may be rather helpless for the first few months. He may never have seen a big modern electric machine, and ,therefore, may not be as efficient as a prdouct of a specialized training school.

The effects of the industries, not only one company, but all companies, are toward broader engineering by making the student understand how it runs, why its runs, and its principles; and not merely about electrical apparatus, if he is an electrical engineer, or mechanical apparatus, if he is a mechanical engineer; but mathematics, and all that is back of human knowledge and literature, which underlies, after all, all of our human society including the engineering student. On the other hand, the student naturally must realize that most of his desire is to take an interest in those pursuits where he can do things; but it is very hard for the average student ta realize in college, if he is a student in English or composition, or a foreign language, why he

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would need to learn French or English in studying electrical engineering or civil engineering. Some never learn it, and, therefore, the tendency of the student is rather to acquire a strictly professional training, and learn about engineering as a plumber learns about plumbing, and not to get an engineering education which fits him to be a member of modern society as every engineer should be. Our world is an engineering world. True, there have been prominent men who had a very narrow education strictly in engineering; and, if you know all about electrical engineering, if you are a very prominent electrical engineer, and very intelligent ,and you are a genius, and know nothing but engineering, you will be very useful to the world.

This is what general education gives; not merely making us animated tools to be used by some bigger mind, but making us capable of using our ability ourselves and getting the benefit ourselves.

Dr. Steinmetz emphasized that the engineer is a most important man in the world's affairs today. In former years civilization had been very artistic but our civilization now is an engineering civilization. Science is the most important subject in modern society, in the minds of men of today. Therefore, the engineer is an important man of today. This being an engineering age, engineers should lead and direct and administer to our civilization. For many, many years engineers have complained that our country is governed from the federal government down to the smallest municipality by the lawyer, by the business man, by the physician, by the minister, but an engineer is rarely found. He is rather an exception. The engineering problems of our country and our civilization are in the hands of the lawyer, of the physician, of the minister, but not of the engineer. The engineer is merely a tool hired to carry out the product of others who are less competent. When, a few years ago, the world war occurred and our country was plunged into the war, it was an engineering war. Then the government, the lawyer, the business man, the minister, the physician, who were administering our nation called upon the engineers. The engineers came from universities, and corporations, from factories, mills, and colleges, to take charge of the government. They organized engineering and won the war. Because, after all, it was the industrial power of our country as organized by engineers which has won the war.

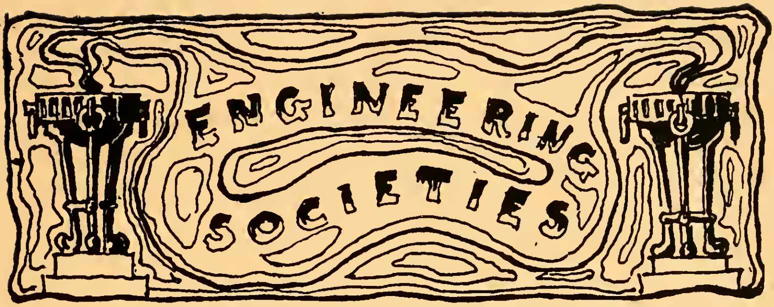
And when the war was over, the engineer went back from the leadership of affairs of the nation, to the college, to the mill, to the factory, to the university, to the corporation, going out of public life; and again the business man, the lawyer, the minister, the physician resumed the running of the affairs of our country. Dr. Steinmetz lays the blame of this condition at the feet of the engineers who do not take an interest in the state of public affairs and who permit the control of government to drift naturally into the hands of the lawyer and business man.

Education, by the definition of the word, means preparing us to take our position within human society. It means to get as much knowledge and understanding as possible of every subject of interest to man. Let us apply that to engineering education, to strictly professional training, learning the laws of nature, understanding them and their application to engineering. The engineer may be, and should be, highly educated, and he should have some knowledge and understanding and interest in everything that is of importance to man; but engineering training does not make him that. The lawyers trade also does not make him an educated man; does not give him a knowledge of all that is of importance to man. But when he goes out to apply the law, he is forced to gain all knowledge and understanding of human life, and get the general education. Thus his profession as a lawyer forces him to gain a knowledge and understanding of the relations of man, which constitute education.

The engineering profession differs from other professions in that it is not broad, but narrow. We must go outside of engineering; we must take interest in matters of general human interest to be competent to utilize our engineering knowledge and ability to benefit our nation and society at large. We must not be professional engineers, but must go outside of engineering and gain a broad knowledge, broad understanding, take interest in everything, try to understand it, and thereby fit ourselves to take the position of leadership within American society, within the world of today; which position we must take to save the world from dishonor.

The above points as brought forth by Dr. Steinmetz will bear deep thought by all engineers and students of engineering and deserve to receive more attention from th engineer who prefers to let the world run itself instead of getting out and doing the active work of government himself.

The students and faculty of Armour Institute may justly feel obligated to Dr. Steinmetz for the message which he gave to the engineers of today and of the future.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President	Ellis C. Cook
Vice-President	I. J. Bready
Treasurer	H. C. Peterson
Secretary	W. N. Erickson

A. S. M. E.

At the last meeting of the A. S. M. E. the usual business was brought before the society and disposed of. A motion was then made and carried that an amendment be made to the Constitution, whereby the Freshmen and Sophomores of the Mechanical Engineering course organize as associated members of the A. S. M. E. with their own staff of officers. Mr. Corydon was elected temporary chairman of the associate body of the society and was instructed to call the first meeting of the associate body.

President Cook then called upon Mr. Stone for a talk. Mr. Stone illustrated and discussed the latest type of turbine driven marine units. In his talk, Mr. Stone described the different types of turbines and other mechanical devices for the operation of a ship. Mr. Stone has had a great deal of experience in the operation of ships and therefore gave a very interesting talk.

Mr. Walters, when called upon, talked upon motor car spring suspension. The talk was very interesting inasmuch as the principle of motor car suspension illustrated by Mr. Walters was an entirely new one and is being worked out by himself. In brief Mr. Walters' idea of car spring suspension being to have the same amount of spring action on the motor car with maximum load as with a minimum load.

Mr. Jackson concluded the talks of the meeting by discussing the absorbtion of shock by automobile tires. The idea brought forth by Mr. Jackson was, to lessen the shock caused by bumps and to have the tires absorb them without serious results to the tires. Mr. Jackson's talk was also interesting as it gave us an insight into the different functions necessary to obtain the desired results.

The policy adopted by the A. S. M. E. this year of holding meetings during the day, has proven very successful with practically perfect attendance at the meetings.

Because of the interest shown in the A. S. M. E. by the Freshmen and Sophomores the amendment allowing them to organize as an associate body was added to the Constitution. The associate body have organized and following is a report on the society and its polity.

Wm. N. Erickson, Secretary.

FRESHMAN AND SOPHOMORE BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President ....Jeff Corydon, Jr.
Vice-President ....'..........Otto Kuehn
Secretary ....G. Donald Wetherbee

A new organization has recently made its appearance among Armour societies and means to make itself better known in a short time. It is the Freshman and Sopormore A. S. M. E. and all Freshmen and Sophomore Mechanicals are invited to become members. In pervious years, membership in the society was limited to upperclassmen, so at a meeting early in November, it was suggested that new society be formed for underclassmen in which they could take an active part. This suggestion met the approval of all present and Mr. Corydon was appointed temporary chairman.

The first meting was held November 14, 1919. It was for the purpose of organization and there was no other program. Officers were elected and after a short talk by the President on the purpose and aims of A. S. M. E., the meeting was adjourned. The policy for the present will be to have the President call upon members for extemporaneous talks on any subject they wish to discuss.

The first regular meeting was held Jan. 9, 1920, and the President called for talks from those present. Mr. Rupprecht told us about fitting a 26 inch shaft into a rotar and the difficulties encountered. Mr. Wenclick followed with a comparison of gasoline and electric automobiles, after which Mr. Erickson described a new electric automobile and its gears. Mr. Seben discussed adhesion between steel and concrete,. Mr. Juraska described a new air chuck for lathes, and Mr. Manske described talking machine speed governors and their production. Most of the talks were short, but the material and delivery were good. The President suggested that President Gebhardt be invited to be present at the next meeting.

G. D. Wetherbee,
Secretary.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF ELECTRICAL ENGINEERS.

Chairman	W. M. Seyferlich
Secretary	H. D. Stevers
Treasurer	J. Smely

On January 9th and 10, 1920, the 357th meeting of the American Institute of Electrical Engineers was held jointly with the Chicago sections of the Western Society of Engineers and the Illuminating Engineering Society.

The program for the two days consisted of a general discussion on "Electrical Distribution for Street Lighting," and several inspection trips about the city. The general discussion commenced in the banquet hall of the City Club at 2 p. m. on Friday, January

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9th, and the meeting adjourned at 10:30 p. m., a dinner and get-together recess being included from 6:00 to 7:30.

Professor Freeman and several Armour men were present and again had the pleasure of hearing an address by Dr. Steinmetz, who "journeyed" here from New York.

The program included the following:

PAPERS—

1. "Series Systems of Distribution for Street Lighting." ....W. P. Hurley, Westinghouse Co., New York
2. "Multiple Systems of Distribution for Street Lighting"....Ward Harrison, National Lamp Works, (G. E. Co.), Cleveland, O.

ADDRESS—

"Constant Potential Series Distribution for Street Lighting"....Dr. Chas. P. Steinmetz, General Electric Co., Schenectady, N. Y.

"Discussion, bringing out experience with recent modifications of the old standard distribution schemes."

The advantages and disadvantages of the series and multiple systems of distribution for street lighting were pointed out by Dr. Steinmetz and Messrs. Hurley, Harrison and Vaughan, the latter discussing the outstanding features of the constant-potential-series system which has been in operation in Milwaukee. Accompanying Mr. Vaughan's discussion were some unique stereoptican views, showing actual photographs of various parts of Milwaukee street lighting system, and also several interesting diagrams and characteristic curves dealing with such questions as the proper selection of transformers and current regulators for the distribution system,etc.

A summation of the advantages and disadvantages of the two practical systems for distribution in street lighting as given by the various authors and speakers would appear somewhat as follows:

For Series systems of distribution the advantages embodied are:

1. Effectiveness.
2. Simplicity of transmission and control.
3. High electrical efficiency of lines and lamps.

The disadvantages are: (1) High cost of line per dollar of income; (2) High voltage; and (3) Special lamps.

For parallel or multiple systems the advantages are:

1. Widest choice in number and size of lamps to be connected to circuit.
2. Ease of adding more lamps or lamps of higher voltage.
2. Simplicity and low cost of fixtures and accessories.
4. Safety.

The one great disadvantage of the multiple system, as far as street lighting is concerned, lies in the methods of control; that is, there must be a "fuller standardization of suitable methods of control applicable generally to existing electrical power distribution systems."

The general consensus of opinion is, therefore, that the ideal system ultimately should be one in which a highly efficient standard lamp may be operated from the existing multiple distribution lines necessary for the lighting of residences and factories, with the addition of reliable and inexpensive controlling devices for turning the lights on and off.

It is asked that special attention be given to the characteristics desirable in such controlling apparatus, as outlined by Ward Harrison in his paper, "Multiple Systems of Distribution for Street Lighting," which appeared in the January issue of the A. I. E. E. *"Journal."*

"The Journal," by the way, is the new name for the monthly Proceedings of the A. I. E. E., and not only has the name been changed, but also the page dimensions and scope of the publication have been greatly enlarged. The dimensions of the new form of proceedings have been increased to 9 by 12 inches, which is the generally adopted standard size for technical publications.

Besides the fact that it is more economical to publish the same amount of material on pages of a larger size than on the size formerly used, the larger page also permits a more attractive typographical display, a better arrangement of tabulated matter, and the publication of larger illustrations.

With reference to the "New Journal," an editorial in the first issue substantiates many of the statements that were heavily emphasized by Dr. Steinmetz before an Armour assembly, on October 31, 1919: "The improvements in the Journal and in other activities of Institute, as recommended by the Committee on Development, *reflect the trend of the times. The predominating* *idea of today is social progress.* The engineer, because of his training and experience, is particularly well qualified to analyze the facts and draw conclusions. There is a general feeling, however, that the engineering profession has refrained from contributing the complete service of which it is capable in the consideration of the great social and economic problems which underlie human progress, and which require for their solution the application of engineering principles and methods."

"*The leaders in the engineering profession are men who have been most active in their respective professional societies.* Their ability for effective collective effort has been developed to a large extent by their activities in the Institute and in similar organizations. The *Journal* is one of the instruments provided by the Institute for the exchange of ideas, and it affords an opportunity for the individual engineer to contribute for publication something of interest and value from his experience in exchange for the ideas which he receives from other contributors."

The Publication Committee will therefore be glad to consider for publication contributions similar in scope to those published in this issue, in which a beginning has been made in the direction indicated. Additional improvements are under consideration, the development of which must necessarily be gradual and within the available income of the Institute applicable to publications. It is expected that the future issues of the *Journal* will constitute even more fully than the monthly Proceedings and the annual Transactions have in the past, an authoritative history of developments in the electrical engineering art and the related sciences, upon which evolution in the electrical industry is based."

WALTER M. SEYFERLICH,
Chairman A. I. E. E.

WESTERN SOCIETY OF ENGINEERS. THE ARMOUR BRANCH OF THE

The old Armour Civil Engineering Society now has a new title and broader fields have been opened to its members. Since our new parent body has accepted us we have elected the following officers:

President	W. J. Wignall
Vice-President	E. Anderson
Treasurer	J. Frank
Asst. Secretary	W. K. Lyon

Due to their efforts we have had several splendid meetings during the semester. Fred Hertwig and Homer Anderson gave us a very inteersting talk on the construction of concrete highways. Prof. Penn told us how to avoid many pitfalls when we begin to write theses. Prof. Reinert gave us a very clever talk on "Estimating," and Prof. Wells told us quite a few things about "Selling Bridges." The personal equation which entered into these talks was invaluable.

Through our efforts Mr. Franklin Pearse of the Chicago Sanitary District came to the Institute and explained the "Activated Sludge Process" used by the Sanitary District. The lecture was attended by many "Chemicals" and "Mechanicals" and we felt well repaid for our efforts.

We will begin a new fiscal year the second Monday of the second semester. We are losing a good man in Dasing, who has finished school.

The membership committee is out after the Sophomores who are invited to become participating members and enjoy the benefits derived thereof.

THE CHEMICAL SOCIETY OF THE ARMOUR INSTITUTE OF TECHNOLOGY

E. G. Vogt	President
E. F. Winter	Vice-President
W. J. Bentley	Secretary
P. L. Stern	Treasurer

The Program Committee has obtained several fine speakers who will address the society during the second Semester. The officers will be pleased to receive suggestions from the members concerning their preferences as to subject or speaker.

It is the purpose of the society to encourage addresses by members who feel they have a subject of interest to the society and we earnestly request them to signify their desire. The

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value of such work to the individual is often underestimated. It is the great fault in the average technical man that he is unable to express the results of his work in a concise and convincing manner. On this account he is denied the advancement and remuneration bestowed on others who can give their ideas the force and prominence required. Amongst the mass of scientific training the student receives, this feature in this education has been left in the care of the Engineering Society to which he belongs. It is earnestly hoped that the members will appreciate this and not neglect their work in this direction. If they cannot bring themselves to present a paper, they should at least try to inform themselves on the subject previous to the lecture and take a part in the subsequent discussion.

The Seniors have had the advantage of several inspection trips during the first Semester. Among the plants visited were:

International Lead Refining Co., at East Chicago, a subsidiary of the Anaconda Copper Co.

American Maize Products Co., at Hammond.

Pope Sugar Beet Factory, at Riverdale.

Holman Soap Works, at Chicago.

Armour Soap Works, at Chicago.

Armour Glycerine Plant, at Chicago.

The officials at each plant were very accommodating, and we feel that all who availed themselves of the opportunity obtained a good idea of the process.

Thesis subjects that have been announced up to date for the Semester, Chemical Engineering Dept., are:

The recovery of resorcinol by extraction from dry sodium salts, by Joseph M. Bernstein.

The electrolytic oxidation of ortho nitro toluene, by C. W. Muehlberger.

The estimation of benzol in the presence of paraffin hydrocarbons, by W. T. McCauley.

The investigation of a zinc alloy, by P. L. Stern and W. J. Bentley.

The chemical oxidation of ortho nitro toluene, by Wm. Eagle and H. F. Klemm.

The production of anthrarufin, by D. H. Podolsky.

Oxidation of Geraniol to Geronial, by A. L. Lyon.

The members of the faculty have shown a willing spirit of co-operation and we wish to thank them for their good will.

W. J. Bentley, Secretary.

The Civil Department has increased amazingly during the last year, and with our new affiliation with the Western Society of Engineers we give great promise of success.

William K. Lyon, Asst. Secretary.

ARMOUR RADIO ASSOCIATION

The Association is now firmly on its feet and is pushing forward zealously toward its goal. The radio set has not yet been completed; however, experiments have been made by the members with a view of determining the proper arrangement of apparatus and the suitability of an antennae location. The results being highty satisfactory, the Association is now taking its first step in the installation of the station.

The location of Armour Institute for radio purposes is one of the most advantageous in Chicago: on account of its elevation above all other structures in the vicinity and the absence of iron framework in them, grounding will cause little damping of signals. It is planned to stretch the antennae from the elevator shaft on Machinery Hall over the main building; such an antennae would have a fundamental period sufficient for the easy reception of signals of the highest wave-lengths, if proper loading is used.

At the request of Prof. Wilcox, the use of the electrical department's photometry room was kindly given to the Association by Prof. Freeman. Proper location for a safe and efficient set-up of the radio aparatus has heretofore been the main difficulty; the phomtometry room affords an exact solution of the problem and puts the radio men under favorable conditions to advance the work rapidly. The only handicap is lack of time; since time is the prime factor in the construction of a station, rapid erection of the outfit is out of the question. Nevertheless the work will be done in an engineering manner in accordance with the principles of the organization. So it should not be a surprise to anyone when, in due time, "POZ" comes roaring in and goes echoing along the corridors.

Nor in the enthusiasm of station installation have other ideals been forgotten. The topic of discussion at the next meeting will be "The Economy and Reliability of the Various Types of Current Supply for Radio Valves." This is a vital question in which every radio amateur is interested and the discussion promises to result in an excellent solution. With the old "Ham" spirit stronger than ever, the Armour Radio Association is looking forward to a successful future. Richard J. Grant.

THE ARMOUR ARCHITECTURAL SOCIETY

The Armour Architectural Society held its annual initiation and banquet on the afternoon and evening of Tuesday, Nov. 24th, 1919.

After a very spirited initiation and lively discussion there followed a very fine banquet in the Art Institute Refrectory.

We were very fortunate in having with us Mr. E. S. Campbell, Mr. Zettler and Mr. E. F. Taylor of the Chicago Plan Commission. After the banquet. Mr. Campbell gave a very fine talk, principally to the freshmen, on the necessary qualifications for a successful architectural career.

Then folowed an illustrated lecture on the proposed Chicago plan; a lecture that was not only very interesting but appropriate, as the Architects are all vitally interested in he new proposed work which will so vitally effect Chicago's future.

We are indebted to Mr. E. F. Taylor for his fine talk and we hope that he will succeed in bringing about the realization of the fine conception of the Chicago Plan.

A new and surprising spirit of activity and work has for some *unforeseen reason* developed among various members of the Senior Class.

Science fact!

We observe that:—

Feminine popularity, especially in business positions does not increase with severity and lack of a sense of humor.

What say, ye Architects!

The effect of the war seems to have dampened the ardor of Freshmen for undue playfulness. Not that Mr. Lautz objects, but it merely surprises him.

It is with gratification that we observe how high the standard of the Freshmen work has been this year. Keep up the good work.

There isn't a great deal to say about the Junior Class, except that they seem to be well aware of the fact that they cannot be much more perfect than they are; likewise that the Seniors cannot be much worse.

Due to the interest of our Faculty—Mrs. E. S. Campbell, Mr. Earl H. Reid, Mrs. Wm. H. Lautz, Mr. Emil G. Zettler, Mr. Kriehbiel and Mr. Talmadge—a prize of $35.00 in Architectural Books was made the incentive for a very interesting and instructive decorative problem. A tapestry to be hung in the trustees' room of the new Field Museum commemorating the world's Columbian Exposition.

The Seniors are now working on the annual $250.00 Troneberg Scholarship Prize problem, which, due to its interesting and practical nature, promises to have various solutions.

W. J. O'Connor, Press Rep.

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Publications Reviewed

We wish to call the attention of our readers to the following recent publications of the Bureau of Standards which are now ready for distribution:

1. "Application of the Interferometer to Gas Analysis."
Technologic Paper No. 131.

It is only within recent years that extended practical application of the physical methods to chemical analysis has been made. This has been especially true in the case of gas analysis. One of the most useful of the physical methods is that of gas interferometry. The author has described a new method of calibrating the gas interferometer, which greatly simplifies and extends its use. The paper discusses the simple relations which exist between the properties of the gases and the indications of the instrument, also giving examples illustrative of its use.

2. "Bibliography of Scientific Literature Relating to Helium."
Circular No. 81.

This bibliography contains practically everything published up to January 1, 1919, except reviews and other articles containing no original work which were published in inaccessible foreign journals and contained no material which was not available in English or American publications.

3. "Cadmium Electrode for Storage Battery Testing."
Technologiv Paper No. 146.

In the operation and testing of storage cells, it is frequently important to know the individual potentials of the positive and negative plates. No standard method has been recognized. The results obtained with the cadmium electrode are often contradictory. This investigation has been made to determine the reliability of the cadmium electrode and the errors in measurement to which it is subject. The standard electrode used was the mercurous sulphate half-cell. It was found that the most serious error in using the cadmium electrode is due to polarization. By measuring the potential of the negative plate and computing the potential of the positive plate from this and the cell voltage, the most serious error of the cadmium electrode can be avoided, even when using an ordinary voltmeter. This investigation deals only with the accuracy of the cadmium electrode and does not discuss the cadmium readings with reference to the age or condition of the battery.

4. Constitution and Metallography of Aluminum and its Light Alloys with Copper and with Magnesium."

Scientific Paper No. 337.

Aluminum and its alloys have been the subject of much investigation during recent years, in the course of which the principal features of the constitution of most of the binary alloy systems with aluminum have been determined. The authors have undertaken to determine the solubilities of a number of aluminum compounds such as $Ca\ Al_3$, Mg_4, Al_3 and $Fe\ Al_3$, at different temperatures and then to establish the missing solubility-temperature curve of these compounds in the equilibrium diagram.

5. "Determination of Free Carbon in Rubber Goods."

Technologic Paper No. 136.

The method consists essentially in removing the rubber and much of the organic matter by treatment with nitric acid. Constituents other than carbon which remain and would show ignition losses are removed, in so far as possible, by treatment with various solvents. Because of the attack on carbon by nitric acid, the ignition loss represents about 105% of the carbon originally present. Thus corrected, the results, though not absolutely accurate, are sufficiently so for commercial work.

6. "Electrolysis in Concrete."

Technologic Paper No. 18.

During the last few years attention has been called to the possibility of damage to reinforced concrete structures by stray current from electric railways and other power sources. With this in view an investigation was made, consisting of three parts, as follows:

A. Laboratory investigation relating to the nature and cause of the phenomena produced by the passage of electric currents through concrete.

B. Investigation in the field with the view of establishing the probable extent of the danger in practice and the circumstances under which trouble is most likely to occur.

C. A study of the various possible means of mitigating trouble from this source, leading to specific recommendations.

7. "Principle of Radio Transmission and Reception with Antenna and Coil Aerials."

Scientific Paper No. 354.

The functioning of the two principal types of radio aerials is worked out quantitatively from fundamental electro-magnetic theory. Experiments have verified the formulas and conclusions presented. Formulas for the current received in either antenna or coil serial in terms of current in either type of transmitting aerial are given, as well as comparison formuals giving the relative performance of antenna and coil aerials under various conditions. The advantages of the condenser type of aerial are presented. The theory and nature of radiation are discussed and applied to the elucidation of some current fallacies. The basic principles of design of aerials are given. Desirable lines of future research are pointed out. The use of the coil aerial as a direction finder, interference preventer, reducer of strays, and submarine aerial are not among the subjects treated.

8. "Thermal Expansion of Insulating Material."

Scientific Paper No. 352.

This paper gives data on the thermal expansion of some of the more important insulating materials.

In most cases the expansions are too irregular to justify the use of the general quadratic equations.

A knowledge of the thermal behavior of these materials is essential before assembling them in certain types of apparatus subjected to wide temperature variations.

The most striking peculiarities are:

(a) The wide range in the values of the coefficients of porcelain from 1.6 to 19.6 millionths per unit length per degree centigrade.

(b) The three varieties of expansions for porcelain: namely, straight line, concave and convex expansion curves.

(c) The shrinkage and the loss in weight of the phenol and similar compounds when subjected to excessive heat treatment.

(d) The permanent growth and variations of different marbles when subjected to heat treatment.

(e) The negative coefficient of expansion of marble at low temperatures.

9. "Variation in Direction of Propagation of Long Electramagnetic Waves."

Scientific Paper No. 353.

This investigation was an outcome of a study of the properties of an extremely long-wave direction-finder coil, with a view to determining the feasibility of using such long-wave direction-finders on large aircraft on long flights, such as, for instance, a trans-Atlantic flight.

A comparison is made of the relative accuracy of settings obtainable with the two-coil maximum and the usual single-coil minimum method.

10. "Annual Report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1919."

Miscellaneous Publications No. 40.

THE ALUMNUS

Being that part of **The Armour Engineer** devoted to personal mention of the Graduates of the Aromur Institute of Technology and to the affairs of the Armour Alumni Association.

Communications should be addressed to John J. Schommer, 33rd and Federal Streets, Chicago, Ill.

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The midyear Armour Alumni Association was held at the City Club, January 17th. The dinner was served at 7:30 p. m. One hundred and thirty members were present.

Allen Benedict was toastmaster and proved a success. He led the singing and put real spirit into it.

Mr. Franklin de Beers, '04, and Mr. R. J. Dunham, who were to address us, were unavoidably absent. Mr. de Beer's speech was read by Mr. W. T. Dean. The topic pertained to the assistance alumni may give and should give their Alma Mater.

Dr. Frank Wakely Gunsaulus then spoke to us about the brilliant future of our Alma Mater. His address was as follows:

"As we now see it, a mighty opportunity came to the Armour Institute of Technology when we discerned in 1893 the facts and forces which led to the great war and discovered what proved to be our place and influence. It was indeed a war of engineers, as we prophesied.

"The Institute, at twenty-five years of age, an infant as educational functions are rated, had to do with chemical, electrical, and other allied mechanical projects, which gave us an international position. We certainly could not have done our part, and remained as we were, a school of girls and boys. It was a costly change, but worth all it cost when we received our charter as the Armour Institute of Technology.

"Not until a few days ago have we been able to consider legally inviting our alumni to their normal part in the guidance and protection of our beloved alma mater. The Armour Institute of Technology is indeed your mother, and you must help support and strengthen her in the way marked out by the experience of other such institutions, when the new opportunity is thoroughly in hand. As the old opportunity was one which proves to have been a preparation for war and victory, so the vastly larger and new opportunity seems one of peace and its greater victories. No such institution has so many obligations to the country. For example, in Civil Engineering, we must contemplate Chicago as a European port; the line of communication between the lakes and the gulf making this a center from all directions, as it never has been before. The use of unimagined resources of water power must help to solve the coal problem. We are handling coal as barbarians now. Physics and Chemistry have unmapped realms of force beyond the X-Ray and radium. All the other departments of technical skill and study, to meet our opportunity and duty here in the Mississippi Valley, demand not a big school, but a great school—I should say of about a thousand high grade students. As sources of supply, we have the high schools, and especially the technical high schools. It is no secret that higher up, the universities will attend to the realm of pure research and hand down to us from above their discoveries and methods and determinations.

If you will be patient, you will have reason for rejoicing, and when you see me again at such a meeting as this and know what I now have within me, which is bursting for statement, you will say I was pretty good on this occasion."

Later on the Doctor said: "If as you say, you wish to do more for the Institute, I would advise your raising money for an Alumni Building, in view of the facts to which I can only refer."

John J. Schommer,
Secretary.

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S. T. Corey, '99, is now Assistant Bridge Engineer of the Chicago, Rock Island & Pacific Roalroad, with offices at the LaSalle St. Station.

Wm. D. Matthews, '99, is now Chief Engineer, Chicago Board of Underwriters, 175 W. Jackson Blvd., Chicago.

Wm. T. Dean, '00, is President of the General Combustion Co., Monadnock Bldg., Chicago.

F. H. Bernhard, '01, is now Managing Editor, Electrical Review, 53 W. Jackson Blvd., Chicago.

Elijah Harris, '02, is Vice President, Electrical Material Co., 618 W. Jackson Blvd., Chicago.

Arthur Wagner, '03, is President, Arthur Wagner Co., 706 S. Dearborn St., Chicago.

E. R. Weber, '03, is now Sales Engineer, Bucyrus Co., South Milwaukee, Wis.

Wm. S. Taussig, '03, leaves for Japan and China shortly.

L. J. Byrne ,'04, is President, Anson-Byrne Co., Otis Bldg., Chicago.

H. W. Clausen, '04, is General Office and Credit Manager, C. D. Osborn Co., 2201-11 Wabausia Ave., Chicago.

G. P. Lennartz, '05, is with the Dept. of Research, Sears-Roebuck & Co., Chicago.

F. A. Putt, '05, is Sales Engineer, Allis-Chalmers Mfg. Co., People's Gas Bldg., Chicago.

Grover Keeth, '06, is Mechanical Superintendent, Victor Chemical Works, Fisher Bldg., Chicago.

H. L. Krum, '06, is now General Manager, The Morkrum Co., 1410 Wrightwood Ave., Chicago.

E. F. Gillette, '06, will be in Pasadena, Cal., until June.

T. S. Ford, '06, is now Asst. Engineer, Board of Local Improvements, City Hall, Chicago.

A. H. Boehmer, '07, is now with Swenson Evaporation Co., Monadnock Bldg., Chicago.

C. U. Smith, '07, is now Asst. Engineer, C., M. & St. P. R. R., Union Depot, Milwaukee, Wis.

W. S. Furry, '07, is now President, Ohio Injector Co. of Ill., Monadnock Bldg., Chicago.

F. G. Heuchling '07, is a Member of Staff, System and Organization Dept., Arthur Young & Co., 116 S. Michigan Ave., Chicago.

G. C. Burge, '08, is now Chief Draftsman, The Arnold Co., 105 S .LaSalle St., Chicago.

R. B. Wendell, '07, is now Asst. to General Sup't, Public Service Co. of Northern Ill., 72 W. Adams St., Chicago.

E. W. Chamberlin, '09, is now with the United States Gypsum Co., 205 W. Monroe St., Chicago.

W. F. Conlin, '09, is now in the Open Hearth Dept., American Steel & Wire Co., Donora, Pa.

A. C. Riker, '09, is now Asst. Cashier, Wyoming National Bank, Casper, Wyo.

B. F. McAuley, '09, is with Republic Flow Meters Co., 565 W. Washington St., Chicago.

H. E. Beckman, '09, is now Asst. Engineer, C., M. & St. P. R. R., Railway Exchange Bldg, Chicago.

H. C. Smith, '09, is now Sup't., North Station, People's Gas Lige & Coke Co., 1122 Crosby St., Chicago.

G. A. Grassby, '09, is Mech. Engineer, Lockwood, Greene & Co., Engineers, Detroit, Mich.

R. G. Eliel, '10, is with Wolfley & Eliel, Architects and Engineers, 619 Stewart Bldg., Rockford, Ill.

H. W. Martin, '10, is Industrial Engineer with C. F. Pease & Co., Chicago.

Duvall Williams is now Asst. Eng'r, M. of W. and Eng'r of Track and Roadways, Chicago, North Shore & Milwaukee R. R., Highwood, Ill.

J. M. Eckert, '10, is now Bus. Manager., Service Dept., Alamo Farm Light Co., 6 N. Michigan Ave., Chicago.

W. J. Baer, '10, is Sales Engineer, Illinois Engineering Co., Chicago.

M. A. Smith, '10, is now Director of Education, United States Gypsum Co., 205 W. Monroe St., Chicago.

Oscar Erickson, '11, is with the Drumm Construction Co., 2117 Fisher Bldg., Chicago.

Herbert Sieck, '11, is now Asst. Gen. M'gr., American Cocoanut Butter Co., Chicago.

H. N. Parsons, '11, is Chief Engineer, U. S. Ball Bearing Mfg. Co., Chicago.

Max L. Lowenberg, '12. is now Structural Engr. with Lowenberg & Lowenberg, Architects and Engineers, 29 S. LaSalle St., Chicago.

E. C. Holden, '12, is in Engineering Accounting, C., M. & St. P. R. R., Chicago.

D. F. Holtman, '12, is Associate Editor, "The American Contractor," 6 N. Michigan Ave., Chicago.

G. R. Meade, '12, is now Asst. Mang. Constr., H. W. Johns-Manville Co., 18th St. and Michigan Ave., Chicago.

C. L. Canman, '12, is Assistant Engineer, Underwriters' Laboratories, 207 E. Ohio St., Chicago.

P. L. Keachie, '12, is in Construction Dept., The Willys Corporation, Elizabeth, N. J.

J. Aeberly, '13, is now Ventilation Engineer, Health Dept., City of Chicago.

J. T. Lucas, '13, is Sales Engineer, U. S. Gypsum Co., Chicago.

P. O. E. Johnson, '13, is Works Manager, Elgin Plant of Wm. A. Field Corp.

C. L. Boetter, '14, is Designer, Bridge Dept., C., B. & Q. R. R., Burlington Bldg., Chicago.

R. W. Whitmore, '14, is Production Mgr., Allen Bradley Co., Milwaukee, Wis.

J. L. Mayer, '15, is now Marine Engineer, U. S. Shipping Board, New York.

L. E. Hibbard, '15, is Sales Engineer, Hyatt Roller Bearing Co., Detroit, Mich.

T. K. Pfafflin, '15, is Engineer, T. E. Brennan Co., Milwaukee, Wis.

Ernest Sieck, '15, is in Engineering Dept., American Coke & Chemical Co., Chicago.

C. A. Knuepfer, '15, is now Superintendent, Automatic Screw Machine Products Co., 416 W. Grand Ave., Chicago.

E. J. Burris, '15, is Sales Engineer, Electrical Eng. Equipment Co., Chicago.

John Jucker, Jr., '15, is now Superintendent with Holabird & Roche, Monre Bldg., Chicago.

J. L. Duffy, '15, is now with the Leonard Engineering Co., Chicago.

Henry Bland, '16, is now with Western Electric Co., Hawthorne, Ill.

F. P. Stranch, '16, is Asst. Supt., Public Service Co., Gas Plant, Oak Park, Ill.

S. E. Sosna, '16, is with Barton Spider-Web System, Chicago.

C. F. Wright' 16, is Asst. to Division Traffic Eng'r, Western Union Telegraph Co., 427 S. LaSalle St., Chicago.

I. S. Loewenberg, '16, is Architect with Loewenberg & Loewenberg, 29 S. LaSalle St., Chicago.

H. N. Simpson, '16, is Asst. Construction Engineer, Sinclair Refining Co., East Chicago, Indiana.

C. E. Stryker, '17, is now with the Ozone Pure Airifier Co., and the Stahl Rectifier Co., Chicago.

E. H. Smith, '17, is now in the Engineering Dept., of Nordyke-Marmon Auto Co., Indianapalis, Ind.

H. B. Maguire, '17, is now a Salesman with the American Steel & Wire Co., Cleveland, Ohio.

Thos. Bjorge, '17, is now Director of Industrial Education, Rockford Public Schools, Rockford, Ill.

R. F. Durant, '17, is Assistant Manager, East Jordan & Boyne City Chemical Co.'s, East Jordan and Boyne City, Mich.

J. S. Kula, '17, is now Inspector, National Inspection Co., 108 S. LaSalle St., Chicago.

Jesse Nitka, '18, is Labor Manager and Industrial Engineer with Scheyer & Co., 412 S. Wells St., Chicago.

A. A. Hofgren, '18, is Commercial Engineer, General Electric Co., Chicago.

S. L. Evans, '18, is Insurance Engineer, Hartford Fire Insurance Co., Chicago.

J. W. Goldstein, '18, is Developing Engineer, International Harvester Co., Experimental Laboratory, Chicago.

R. H. Rensch, '19, is with the General Electric Co., Schenectady, N. Y.

H. E. Jeddy, '18, Sales Engineer, U. S. Gypsum Co., Buffalo, N. Y.

C. R. Schuler, '13, is Distribution Engineer, Commonwealth Edison Co., Chicago.

J. J. Wheeler, '07, is now Head of the Department of Science, Colored High School, Baltimore, Md.

A. L. Robinson, '11, is now Asst. Mgr., The American Well Works, Chicago.

V. S. Persons, '02, is now Treasurer and Sales Agent of the L. A. Norris Co., San Francisco, Cal.

B. C. Hooper, '07, is now Sales Engineer of the American Steel Foundries.

M. I. Anderson, '08, is now Superintendent of the Anderson Bros.' Light & Power Co., Hartford, Mich.

Herbert W. Puschel, '18, is now with the Underwriters' Bureau of the Middle and Southern States, New York City.

Ira J. Turnbull, '07, is now in the Plant Engineering Dept. of the Hudson Motor Co., Detroit, Mich.

S. C. Anderson '12, is now Chief Engineer and Master Mechanic for the Standard Oil Co., Louisville, Ky.

R. J. Hoffman, '10, is now General Superintendent of the Linde Air Products Co., New York City.

C. H. Roberts, '17, is now a partner in the general insurance firm of Isaac D. Roberts & Sons, Beaumont, Tex.

Geo. D. Lewis, '99, is now Contracting Engineer, Buick Motor Co., Flint, Mich.

G. H. Wehey, '08, is now Editor of "The Bulletin of Affiliated Engineering Society of Minnesota," St. Paul, Minn.

C. E. Beck, '11, is southwestern representative of Bush-Sulzer Bros., Diesel Engine Co., St. Louis, Mo.

Fred A. Trask, '19, is Inspection Engineer, Foamite Firefoam Co., New York, N. Y.

L. H. Stein, '05, is now Chief Inspector of the Illinois Central R. R., Chicago.

C. R. Pomeroy, '17, is now Asst. General Supt. of Machinery, Bethlehem Shipbuilding Corp., Quincy, Mass.

Lee Boyd Jones, '07, is now Chief Engineer of the Sunbeam Electric Mfg. Co., Evansville, Ind.

H. A. Drew, '12, is Branch Manager of the Edison Ctorage Battery Co., Minneapolis, Minn.

Guy E. Williams, '11, is now with the International Harvester Co.

J. S. Smalley, '07, is now Supe. of Motor Cars, M. B. & S. R. R. Co., Muscatine, Iowa.

Milton V. Stgg, '07, is District Manager, Delco Light Products, Peoria, Ill.

Walter G. Hoy, '05, Contractor, has located in Detroit, Mich.

J. A. Keeth, '19, is Detail Engineer of the Kansas City Power & Light Co., Kansas City, Mo.

Alexander Webb, '08, is now Asst. Professor of Civil Engineering at the University of Idaho.

Stephen Walker, '14, has returned to civil life and is now

District Engineer of the United States Gypsum Co.

Leroy Enzler, '16, is now in the Sales Dept. of the Cincinnati Repair and Supply Dept. of the Goodman Mfg. Co., in West Virginia.

George Hills, '11, is now a member of Isham Randolph & Co., Consulting Engineers, Managing their southern business.

Arnold H. Smith, '17, is now Research Chemist with the Goodyear Tire & Rubber Co., Akron, O.

Schuyler M. Smith, '11, is now Principal Assistant Engineer, Wabash R. R., 1467 Railway Exchange Bldg., St. Louis, Mo.

L. I. Mohler, '99, is now Proprietor and Manager of the Mohler Machinery & Supply Co., St. Louis, Mo.

C. W. Farrier, '16, is now Architect, Board of Local Improvements, City of Chicago.

H. S. Johnson, '11, is now Secretary of the Monarch Diamond Oil Co., Berkeley, Cal.

A. M. Grossman, '15, is now Secretary and Director of Production of the Kane Mfg. Co., Chicago.

Roy A. Winser, '08, is now Water Engineer, St. L.-S. F. R. R., Springfield, Mo.

Raymond Zack, '11, is now District Engineer, State Highway Commission, Mason City, Iowa.

Donald A. Drozeski, '13, Assistant Plant Manager, Saginaw Malleable Iron Co., Saginaw, Mich.

Henry J. Bremers, '10, is now a member of the law firm of Bremers, Lee, Bremers & Bremers, 707 Keeline Bldg., Omaha, Neb.

Louis H. Flanders, '98, died Nov. 21, 1919.

E. Roger Burley, '13, is now an Automotive Consulting Engineer in Lewiston, Penn.

Charles J. Kehr, '13, is now Sales Engineer for Joseph T. Ryerson & Sons.

E. V. Starkweather, '99, is now Engineer, Schedule Rating Office, 40 Clinton St., Newark, N. J.

V. A. Kerr, '18, is now with the American Well Works, as Asst. Steam Turbine Engineer.

A. Corman, '17, is now Asst. Production Engineer, Groton Iron Works, Groton, Conn.

George H. Patten, '98, is now Vice President and Secretary of the Chattanooga Medicine Co., Chattanooga, Tenn.

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A. J. Mease, '17, is now Asst. General Foreman of the Dye Dept. of the Newport Chemical Works, Milwaukee, Wis.

Frank W. Hook, '14, is now Branch Manager for the Johnson Service Co., in San Francisco.

C. C. Heritage. '14, is now Chemical Engineer of the National Aniline & Chemical Co., Buffalo, N. Y.

Herbert Rose, '09, is now Sales Representative in Arizona and New Mexico for Federal Sign System, Phoenix, Ariz.,

Charles S. Henning, '07, is a member of the firm of Wilson & Henning, Civil Engineers, Sipe Springs, Texas.

Joseph D. Livermore, '10, is now Instructor in Drawing at the University of Wisconsin.

J. G. Larkin, '02, is now Northwestern Manager of Garnett Young & Co., Seattle, Wish.

Milton C. Shedd, '09, is at present Engineer and Superintendent of Construction, Constructing Q. M., U. S. Army, Fort Bliss, Texas.

George W. Chicas, '06, is Secretary and Engineer, Stannard Power Equipment Co., Chicago.

W. E. Weinsheimer, '98, is a Patent Lawyer in Los Angeles, Cal.

Rolland M. Heskett, '02, is Manager of Minnesota Utilities Co., Eveleth, Minn.

Joseph Somlyo, '19, is Professor of Architecture and Art at the Bradley Polytechnic Institute, Peoria, Ill.

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Patrick Brennan.
Arthur C. Buckett, '09.
Fred Clarke, '07.
Marston Curtis, '13.
Alfred A. Ebert, '09.
I. J. Ettenson, '08.
G. W. Fiske, '05.
T. C. Ford, '09.
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F. H. Griffiths, '11.
Warren H. Hamilton, '16.
E. T. Harwood, '02.
F. G. Hazen, '12.
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Percy Hynes, '11.
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N. W. Strale, '12.
J. B. Swift, '01.
C. L. Tarbell, '99.
A. W. Tyler, '05.
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R. S. Ziehn, '13.
E. G. Zilmer, '13.

Owing to the tremendous increase in the cost of publication, and also to the fact that industries are cutting down their advertising budgets, The Cycle is in great financial distress. Therefore, The Cycle takes this opportunity to call upon the "Armour Alumni" for assistance and urgently requests them to exert their influence in obtaining ads from the companies with which they are connected.

Any information pertaining to increasing our advertising copy will be greatly appreciated by The Cycle,
ZAdv. Dept. 33rd and Federal Sts., Chicago.

COLLEGE NOTES

They're a 'going and a 'going fine!

The above statement should unequivocally express the admirable work that is being done in basketball by the Tech Team. Much has been already accomplished during the few weeks of competition with regularly scheduled colleges, and, unless the inevitable happens, the writer verily believes that upon the termination of the basketball program, the Armour institute should have won at least 65 per cent of the games.

At the opening of the basketball season, Mr. Norman Volz, a highly competent athletic coach, was engaged in that capacity for the purpose of developing into shape the men who had been chosen to represent the institute in basketball for the coming year. Numerous aspirants for berths in the squad were carefully drilled for practice and subsequently eliminated or retained, as the coach saw fit to do. Several scrimmages were held in our gymnasium for the purpose of testing out the candidates in various angles of the game. However, after much careful deliberation, the following men have been designated as the Tech Squad:

H. Ahlbeck, R. F.
I. Bready, L. F.
W. Erickson, C.
M. May, R. G.
S. Havlick, L. G.
G. F. Schumacher, R. F.
A. A. Zalewski, L. F.
O. Kuehn, R. G.
J. W. McCaffery, L. G.

Our initial combat in basketball was staged in our gymnasium before a throng of Armour loyalists who crowded the benches and filled in much of the standing space near and about the court.

The Hillsdale College sent its team to meet us in basketball competition. Those basketeers measured up to the standard of athletic quality possessed by a team which usually emerges from a big city. It is interesting indeed to know that there may be found in a jerk-water town like Hillsdale, in Michigan, a group of men whose quick and accurate playing won for them the game. The Armour quintet fought persistently to break Hillsdale's combination; Hillsdale's sharp offensive drive in no wise blocked Armour's way to the basket.

Ahlbeck shot high and sure. It was quite evident that Ahlbeck had been in condition for the game.

Bready, although well wound up for accurate shooting, found it quite difficult to sink the baskets with two or three hundred pounds of humanity on his back at every attempt. It appeared to the spectators that someone had literally marked Ira for the Hillsdale guards.

Erickson held his ground well in spite of the unexpected notice that personal fouls against him were reaching the requisite number.

Mr. Volz earnestly advocates the advisability of overhead shooting at all times. He contends that the ascertainment of distance depends upon that style of shooting, the distance from any point to the basket being easily measured by the player who throws the ball in on overhead manner.

Havlick, substituting for Erickson in the last half of the game. spurted about the floor with the speed of a high powered engine, put into action after a freeze-up.

May, the tallest and heaviest player on the team, withstood much violent flooring. However, it may be "authoritatively" stated that the Hillsdale players took no small spills when their bodies met with May's. It was quite truly said by one of the spectators that "Greek met Greek" at each turn of May's big physical personality. May has been praised for his fearless guarding, and men well skilled in the game have pointed him out as the "wildfire" of next season's tournament.

Schumacher had featured his under-the-basket shots with great success, adding two immediate points to Armour's score in the first half of the game. Although "Shoe's" weight is far below that of any of the other players on the Tech Team, it is hoped that his sure-shot aim will stay with him.

Kuehn was recognized by the official as a substitute for Schumacher when the latter had been advised by our coach to let

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ALPHABETICAL INDEX OF ADVERTISERS.

Page
Armour Institute of Technology 1
Armour & Co. 9
Banning & Banning 6
Brady Foundry Co. 4
Chas. H. Besley & Co. 3
Clarke-McElroy Publishing Co. 11
General Electric Co. 2
Hansell-Elcock Co. 8
Hills, Chas W. 8
Jointless Fire Brick Co. 7
Koehne Studio 10
Leschen & Sons Rope Co. 6
Lufkin Rule Co. 3
Magie Bros. 8
Roebling & Sons Co., John A. 5
Swenson Evaporator Co. 6

THE ARMOUR ENGINEER

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OF THE

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Volume XI Number 3

March, 1920

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The Armour Engineer

VOLUME XI MARCH, 1920 NUMBER 3

THE THOMAS ELECTRIC GAS METER

By Ralph H. Earle, Class of 1917,
Engineer, The Cutler-Hammer Mfg. Company.

General—The Thomas Meter is used for the measurement of gas in large quantities. This meter is an altogether different device from the familiar type used in houses, which latter type, although suited for the service in which it is used, is totally inadequate to measure the gas taken by a city, for instance, or even by a large industrial user, where the quantities may run from a few thousand to several million cubic feet per hour.

The other common types of meters used for large-quantity measurement are the wet-displacement, venturi, orifice and Pitot tube meters. The principles of the last three types are suggested by their names and will not be discussed further than to say that the meters measure the velocity of the gas stream, from which measurement the quantity is derived. The wet-displacement meter, however, operates somewhat like a screw conveyor, and by its rate of turning, measures the volume of the gas passing through it.

Scheme—The Thomas Meter depends upon a distinctly different scheme. This meter warms the gas stream exactly two degrees by means of an electric heater, so that a measure of the electrical energy required by the heater is also a measure of the gas flowing.

This principle is brought out more clearly by reference to Figure 1. This illustration shows a pipe line carrying the gas, and in this pipe is inserted an electric heater. The heater is connected to the power supply in series with a rheostat or regulator and a watt-hour meter. The energy supplied to the heater is

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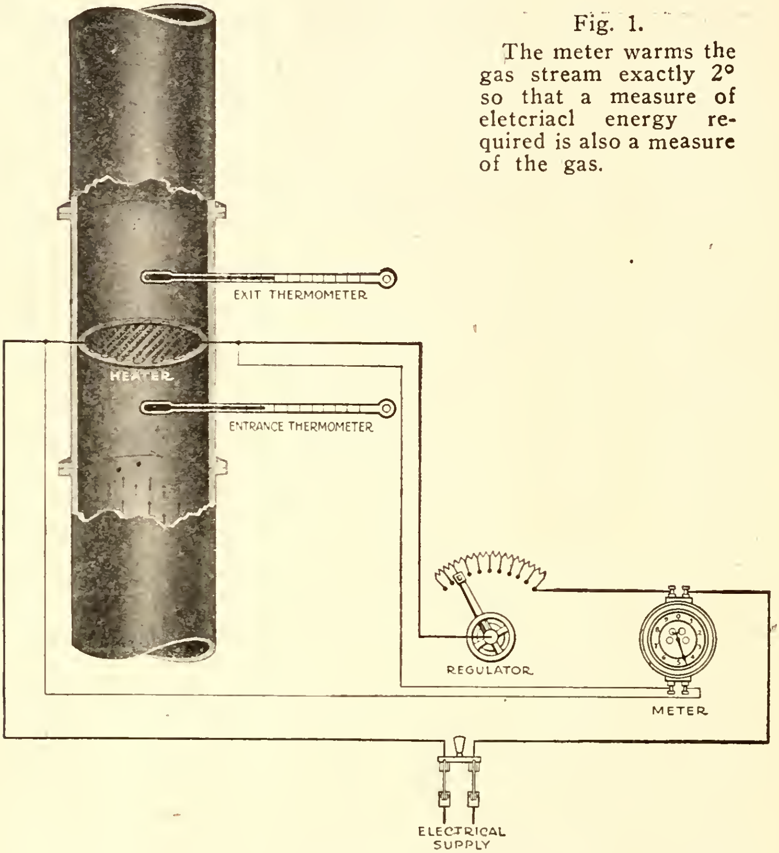


Fig. 1.
The meter warms the gas stream exactly 2° so that a measure of eletcriacl energy required is also a measure of the gas.

Actual Meter—In actual practice the two mercurial thermometers are replaced by nickel wire resistance thermometers which are arranged to control the energy automatically. These thermometers as well as the heater and the housing in which all three of mounted are illustrated in the accompanying photographs.

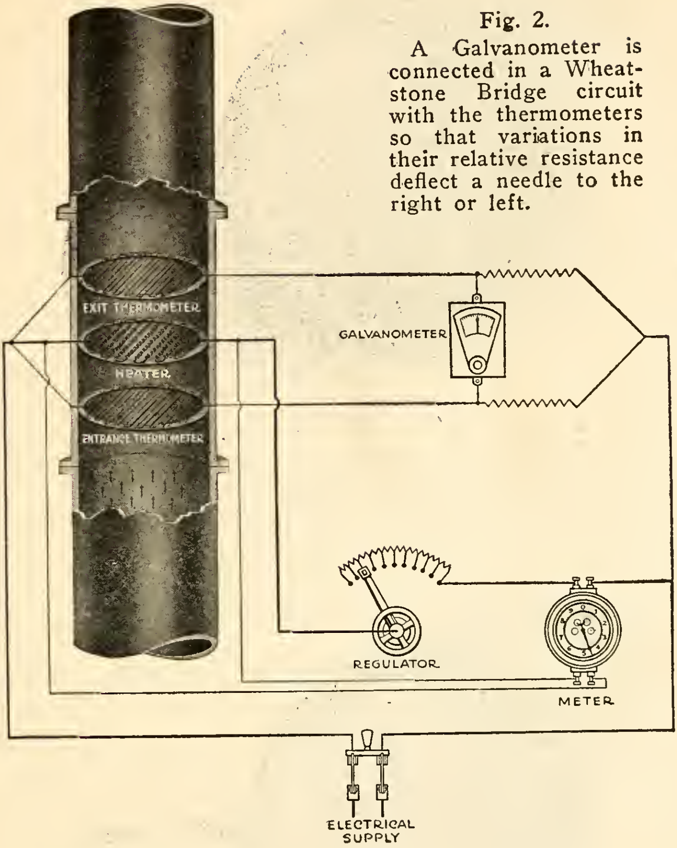


Fig. 2.
A Galvanometer is connected in a Wheatstone Bridge circuit with the thermometers so that variations in their relative resistance deflect a needle to the right or left.

The scheme of the thermometers somewhat simplified, is depicted in Figure 2, which shows the same heater arrangement as before and the two resistance thermometers forming two legs of a Wheatstone bridge. The bridge is balanced when the two thermometers are two degrees apart, but if this temperature-difference changes, due to a change in gas flow, the galvanometer becomes unbalanced; in order that it again becomes balanced, the heater rheostat must be adjusted.

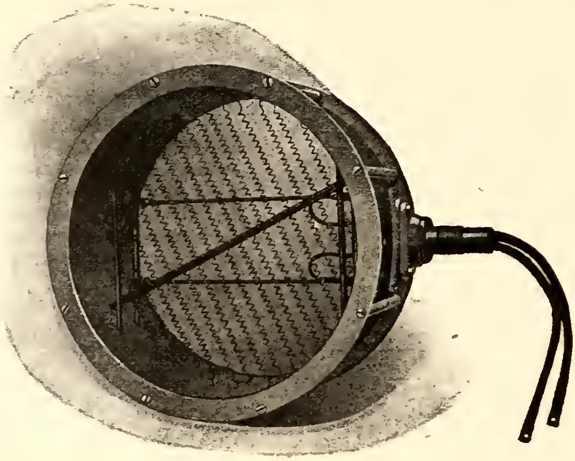


Fig. 3.

The Heater Unit consists of spiral coils or resistance wire wound back and forth inside of an insulating drum. The two terminals are brought out at the side and connections are led from them to the regulator and panel in conduit.

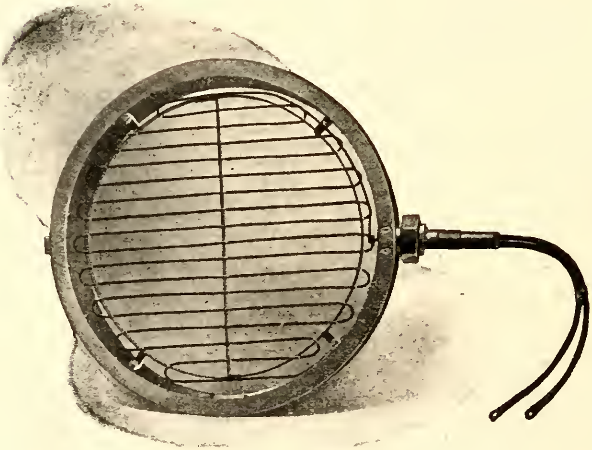
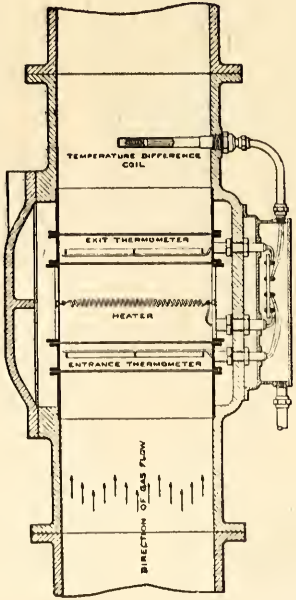


Fig. 4.

The Thermometer Unit consists of a nickel resistance wire encased in a flexible tube which is wound back and forth over a circular frame. The tube is lead covered and sealed so that the nickel wire is entirely protected from the corrosive action of the gas.



The sketch to the left shows a typical Housing with the relative locations of thermometers, heater and temperature difference coil. the connections to which are conducted to the regulating and recording panels in iron conduits. The heater and thermometer units when mounted in the cast iron housing form a portion of the gas passage. The temperature difference coil, shown near the top, automatically corrects for the varying water vapor content in the gas.

Fif. 5.

The two thermometers are exact duplicates but a small resistance, not shown in the diagram, is placed in series with the entrance thermometer. This resistance is called the "Temperature-difference" resistance, and it is of such value that the temperature-rise of just two degrees is necessary to balance the bridge circuit. This resistance is built so that it projects into the gas stream and hence assumes the stream temperature. By designing the resistance to have the proper temperature coefficient, it affects the temperature-rise in such a way as to compensate automatically for changes in specific heat of the gas with temperature and for changes in the water-vapor content of saturated gas.

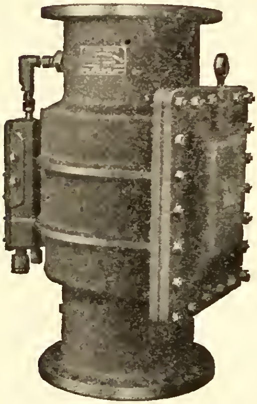
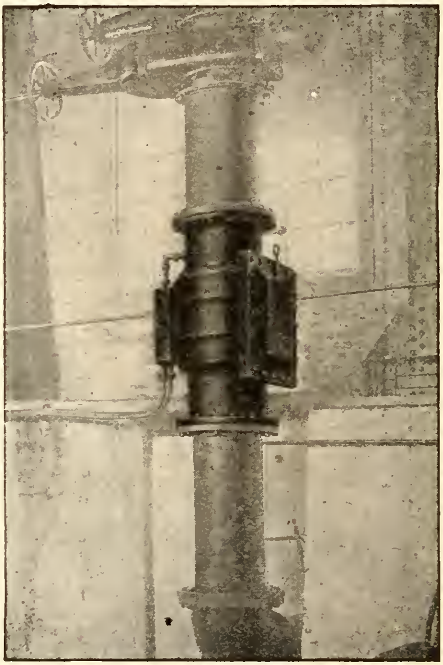
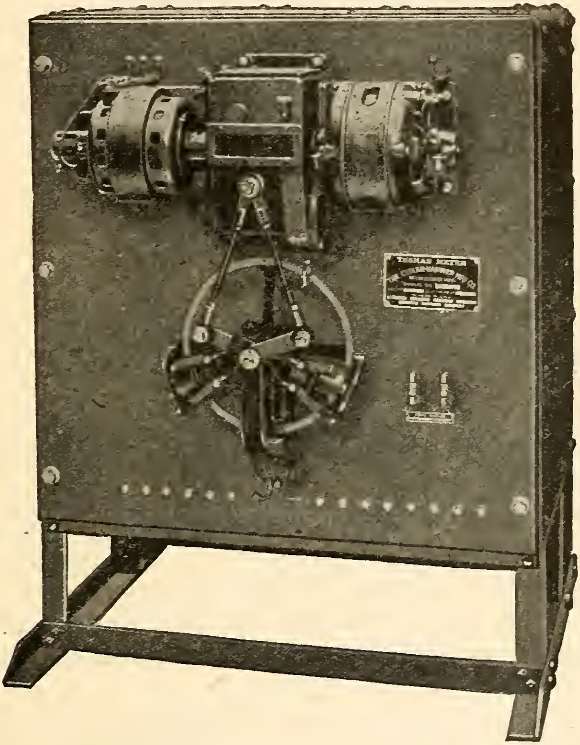


Fig. 6.—Meter Housing



The Thomas Meter Housing is located at any point in the pipe line where measurement is desired. The housing above is installed in the fuel gas line to coke oven battery, Northwestern Iron Co., Mayville, Wis.
Fig. 7.

As for the method by which the thermometers control the energy supplied to the heater, the heater rheostat is built into that part of the meter known as the "regulator," shown in Figure 8. It is arranged that this regulator may be adjusted by a ratcheting device; two solenoids are provided in the ratchet so that the solenoid which is energized determines whether the resistance is increased or decreased. On either side of the galvanometer needle is a clamping contact; if the needle swings under contact, it energies that solenoid which increases the heater resistance whereas if it swings to the opposite contact, the resistance is decreased. In this manner the needle regulates the heat and tends to maintain itself in the neutral position; that is, the energy is so regulated in response to changes in gas flow that a two degree temperature-rise is maintained.

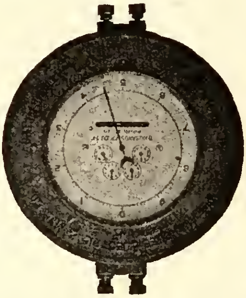


A Regulator responsive to the galvanometer deflections automatically increases or decreases the heater current in accordance with variations in gas flow.

Fig. 8.

The galvanometer and integrating watt-hour meter as well as a graphic meter and controlling switches are mounted on a slate panel; this instrument panel is illustrated in Figure 13.

Structural Elements—From a structural standpoint, then, the meter consists of a housing, which is built into the gas line the same as a section of pipe; the regulator; and the instrument. As these three elements are connected electrically and not mechanically, each may be placed where most convenient and separate from the other two.



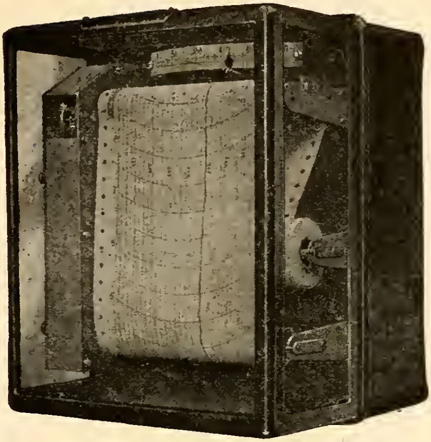
The dial of the Totalizing Instrument shows the gas flow over any given period directly in standard cubic feet.

Fig. 9.

A complete installation is shown in Figures 13 and 14, and illustrates a typical setting of the meter. A common arrangement is to place the housing in the pipe line wherever it is most convenient, set the regulator in some spare corner, and locate the recording panel where the superintendent or the operators can see the graphic chart.

Graphic Chart—The graphic record furnished by the graphic watt-hour meter is illustrated in Figure 11. The graphic record is of particular value in the efficient operation of an artificial gas plant, for it shows the operator just how much gas is flowing at any time, thus enabling him to control his rate of charging to give a smooth uniform working of the plant. It of course, constitutes a permanent and continuous record of the operation and in addition, has proven of value in many instances in showing the existence of trouble.

Accuracy—The precision of the instrument is guaranteed to be within 2 per cent, which figure is the customary one em-



A Graphic Instrument traces a continuous record of the rate of gas flow in stanrard cubic feet.

Fig. 10.

ployed in high grade gas meters. If desired, however, this precision may be increased and a manually controlled meter for laboratory use approaches 0. 2 per cent.

In connection with accuracy, one naturally asks the effect of changes in composition of the gas upon its specific heat and consequently upon the precision of the meter. The fundamental equation of the meter is as follows:

B. T. U. input to heater=Watt-Hours x 3.415=Cubic Feet per Hour x Temperature-Rise x Specific Heat x Weight per Cubic Foot at 30-60.

This equation involves not just the specific heat alone but the product Specific Heat x Weight per cubic foot at 30-60; this product is called the Heat Capacity and is obviously the amount the heat required to warm one cubic foot through one degree. This heat capacity is very nearly the same for all common gases so that the heat capacity of an industrial gas is practically unaffected by the slight changes in composition which occur from day to day.

Furthermore, since the specific heat is little affected by the changes in pressure which occur in commercial work, and the effect of changes in temperature on specific heat are taken care of automatically by the temperature-difference coil as explained before, the meter reads in standard cubic feet of gas directly,

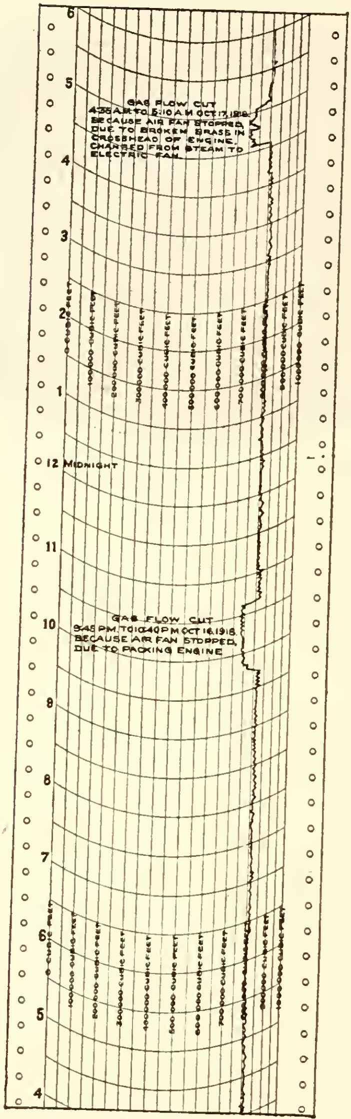
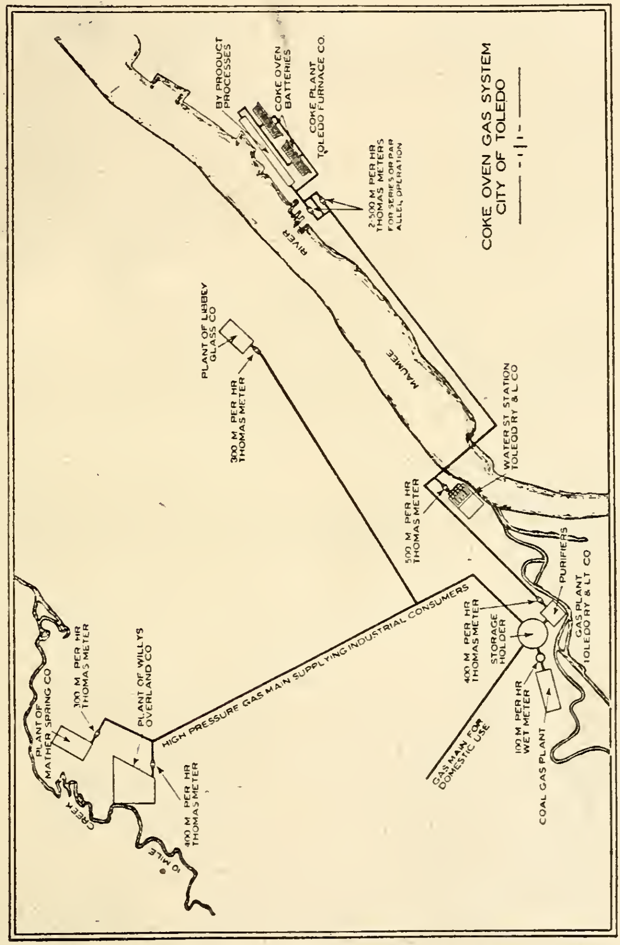


Fig. 11.

Efficient operation is the result of watching the graphic chart and keeping the production of gas at a certain uniform rate. At the same time irregularities or defects are quickly exposed as indicated in the chart above.

independently of the conditions of temperature and pressure of the gas stream.

To determine accurately the heat capacity of a gas under service conditions an apparatus has been developed by which the heat capacity (and specific heat) may be readily measured to within ½ per cent. This apparatus is portable and does not require laboratory conditions for its operation.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CITY OF TOLEDO
BY PRODUCT PROCESSES
COKE OVEN BATTERIES
COKE PLANT TOLEDO FURNACE CO.
2-500 M PER HR THOMAS METERS FOR SERIES OR PARALLEL OPERATION
MAUMEE RIVER
PLANT OF LIBBEY GLASS CO
300 M PER HR THOMAS METER
500 M PER HR THOMAS METER
WATER ST STATION TOLEDO RY & L CO
PURIFIERS
GAS PLANT TOLEDO RY & LT CO
400 M PER HR THOMAS METER
STORAGE HOLDER
100 M PER HR WET METER
COAL GAS PLANT
GAS MAIN FOR DOMESTIC USE
HIGH PRESSURE GAS MAIN SUPPLYING INDUSTRIAL CONSUMERS
PLANT OF WILLYS OVERLAND CO
400 M PER HR THOMAS METER
PLANT OF MATHER SPRING CO
300 M PER HR THOMAS METER
10 MILE CREEK

Fig. 12
Plan of coke oven gas distribution to industrial plants and locations of seven Thomas Meters in Toledo, Ohio.

Energy Consumption—The device requires from fifteen to twenty watt-hours per thousand cubic feet of gas measured; of this amount, twelve watt-hours are used in warming the gas stream, whereas the remainder is used in the control circuits.

Uses—As for the applications of the meter, the most common is, of course, the measurement of city gas and of fuel gas at coke plants and steel mills. Figure 12 shows a map of a system in which several of the meters are used. A coke plant sells its surplus coke oven gas to the local gas company, which company adds artificial coal gas from its own plant and distributes the

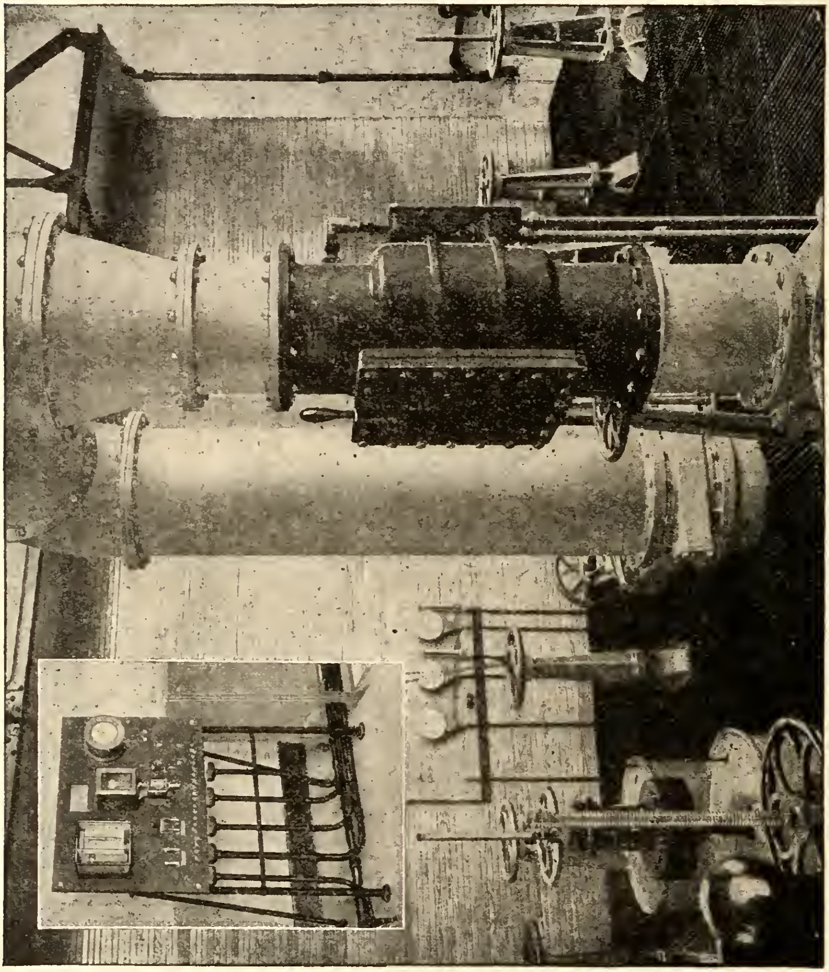

Fig. 13.
Thomas Meter Housing and (above) Graphic and Totalizing Instruments at Malden & Melrose Gas. Co., Malden, Mass.

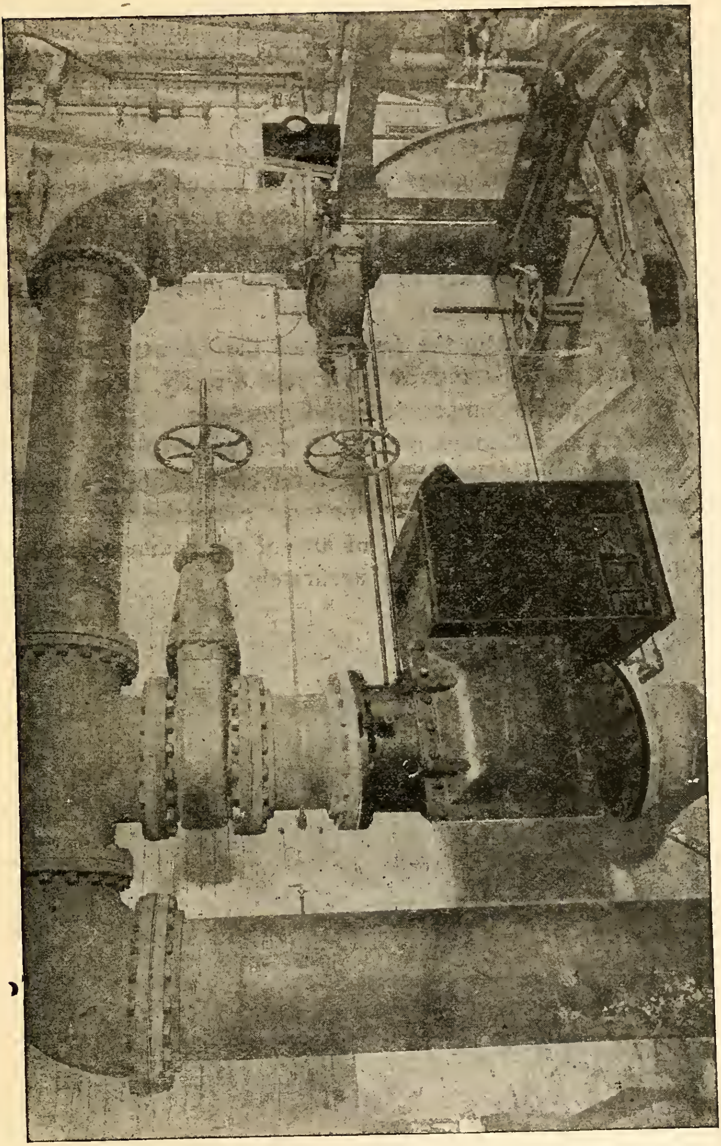

Fig. 14.
Thomas Meter, Regulator and Recording Panel installed at the plant of the Toledo Raiways & Light Co., Toledo, O., for measuring surplus gas supplied to the boilers.

mixture to the domestic and several large industrial consumers. The location of the meters illustrates the common practice in such service.

The Thomas Meter is particularly suited for service in the natural gas fields, when electric power is available. As the meter reads in standard cubic feet directly, no tedious computations and corrections are required. No corrections are required for the widely varying pressures and temperatures occurring in the gas when measured.

Perhaps the most interesting field of usefulness, however, is in the measurement of gases whose flow is pulsating, such as that delivered by a pump. Ordinarily, such gases are quite difficult to measure but the Thomas Meter is able to operate on flows whose pulsations are of considerable magnitude without the use of correction factors.

Summary—To sum up the features of the Thomas Meter:

It measures gas in standard cubic feet directly, being unaffected by changes in temperature and pressure.

It furnishes a continuous graphic record of gas-flow.

It occupies but little space and the three elements of the meter may be separated and placed where most convenient.

It is suitable for measurement of any of the common gases.

It will measure pulsating flow accurately.

TRANSMITTED POWER FOR THE FARM

By F. C. Van Etten, '09,
Designing Engineer, Delta Star Electric Co.

GENERAL

DEMAND FOR FARM LINES

The problem of the supply of light and power to rural consumers from transmission lines is rapidly emerging from the experimental stage, in fact we may say that it is just now graduating from this stage, and further, that commencement will be held next year.

The writer has talked with a number of central station men thruout the middle west and all make the statement that their companies intend to do extensive work in this field during 1920. This work is being undertaken voluntarily by the operating companies at the present time, but behind this effort is the feeling that if they do not do something the farmer will—that is, he will enforce his demands for service either thru the state commissions or by legislation. The rural vote in a number of our states is by no means an insignificant factor in politics.

TRANSMITTED POWER VS. INDIVIDUAL PLANT

This demand on the part of the farmer is only a natural one. This has been fostered by the advent of the small individual plants and the central station interests are deeply indebted to the manufacturers of such equipment for the pioneer work that they have done. But the individual plants have been on the market for a sufficient length of time and in general use in such numbers not only to arouse the rural public to the convenience of electrical power and lighting on the farm but also to prove the worth of such plants. There are a number of farms to which it will be impossible to extend transmission lines for a considerable time. These farms constitute the field of the individual plants and a large one it is. However, the superiority of transmitted power over the individual plant has become of general knowledge among farmers and for this reason they are demanding central station service.

The advantages of transmitted power over the individual plant may be briefly enumerated as follows:

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* From "Nebraska Blue Print."

1. Less ultimate investment.
2. Unlimited supply.
3. Twenty-four hour service.
4. Allows the use of standard 110-V appliances.
5. No attention required.
6. No house or barn space required.
7. No acid fumes, smoke, gas, dust or noise.
8. No oil or gasoline to explode or catch on fire.

The farmer realizes this and is only too anxious to receive this commodity. There is therefore tremendous possibilities for the central station manager in this field. His problem, however, is to finance the line and make its operation a success financially and technically, that is to provide lines and equipment at a moderate price and so that the operation of such will not interfere with his more important duty of rendering service to his municipalities.

FINANCING RURAL EXTENSION

In the past many of the central station managers have failed in reaching the farmer because they were laboring under the impression that this class of service must be furnished under conditions usually found in the cities and small towns. They attempted to finance the entire proposition and assumed all risks when setting the rates. Experience has shown that those rates were usually set too low with a consequent dissatisfaction with this class of service.

Today, however, they realize that there is little in common in the matter of supplying electrical energy to the rural consumer and the inhabitants of cities and small towns.

The established practice of today is to require the farmer to finance the line and the substation equipment. Risks are eliminated wherever possible and the rates are set high enough to cover the balance of the contingencies. Where possible, the farmer is required to shoulder all risks, which is where they rightfully belong. Many central station men even advocate that repairs to the line and other maintenance work be charged directly to the farmers, thereby eliminating this uncertainty from the rate question. The tendency is to meter on the high tension side so as to eliminate the uncertainty of core losses and their effect on the rate schedule.

By so shouldering the responsibility on the farmer, this field becomes financially possible, the supply of light and power to the farmer becomes attractive to the central station manager and the farmer is able to obtain what he most desires.

TECHNICAL FEATURES

Knowing therefore that under such conditions this class of business can be made a financial success, the central station manager then gives his attention to the technical features in order that it may be a success from the operating standpoint.

LINE CONSTRUCTION

Where the farmer pays for all equipment, the operating company is not required to adapt the cheapest line and substation construction. The tendency to do this in the past was a large factor in the failure of farm lines from an operating standpoint. The type of construction adopted, while not considered good enough for the more important trunk lines, is nevertheless very satisfactory for farm line service. It is made substantial so as to reduce the chance of line failure, thereby reducing service interruptions and the liability for injury to the public.

PRIMARY VOLTAGE

For serving farm loads transmission voltages of 2300, 6600 and 13200 have come into extensive use. Just as operating men have learned that they must charge sufficiently for this class of service, they have also learned that they must use the higher voltages for this work.

As would be expected the first attempts in this business were to serve farm loads at 2300 volts by short extensions from city lines. Those that have made the greater efforts in this field have learned that this voltage soon limited the extension of farm lines. The limit of 2300 V service lies in the regulation of such lines rather than in the line loss. It is this feature that is often overlooked when determining upon the proper voltage.

The extension of farm lines naturally leads to the serving of small towns and it is really a question if 6600 volts which is not too low. It now appears that the stadard lines voltage for rural service will be 13200. This voltage presents no serious operating conditions and the transformer losses while larger than with the lower voltages are yet within reason.

Under the policy of requiring the farmer to finance the line and substation equipment the voltage does not become a handicap to the central station companies in the matter of extensions. The farmer will finance a 13200 volt line as readily as he will finance a 2300 volt or 6600 volt line However, if a 2300 volt or 6600 volt line is installed at first it is a very difficult if not an impossibe task to get the farmer to assume the cost of the change to the higher voltages often found advisable or necessary.

The advisability of using the higher line voltages may be more forcibly brought to one's attention by the statement that may be served with 6600 volts an area approximately nine times the size and with 13200 volts, an area approximately thirty-six times the size of the area that can be served wtih 2300 volts.

TYPE OF SYSTEM

GROUNDED SINGLE PHASE

This system has been used to a small extent but generally in the case of the small central station company, which has attempted to finance all construction. It is not recommended principally on account of its large interference with telephone lines and its use should never have been considered when the financial burden is borne by the farmer.

METALLIC SINGLE PHASE

This system is being used quite extensively but its use should be limited to short lateral extensions.

THREE PHASE FOUR WIRE

This type of system has not been used to any great extent as yet but its use has been contemplated. It is mentioned here rather as a caution against its use. This system is coming into prominence on the higher voltage lines of extended length where the charging current to ground becomes an important factor and where it becomes necessary to definitely establish the neutral point of the system. But for farm lines using the lower voltages for relatively short distances its use is not recommended.

THREE WIRE SINGLE PHASE

This system has been extensively used and undoubtedly is the proper one. A combination of this system for the main artery and metallic single phase for short laterals is the logical system to use. This system gives less severe operating conditions for fuses, oil switches and lightning arresters and has the advantage that it can be operated temporarily with one wire grounded.

It, therefore, requires less tree trimming which is quite a factor in extensive service to rural consumers.

FARMER'S SUBSTATIONS

The farmers' substation is perhaps more important than the line construction, voltage and type of system. As mentioned above, farm lines will be extended from town to town and the importance of continuous operation becomes more pronounced. It has been this factor which has often caused central station managers to refuse service to farmers even though a line runs in front of a farmer's home. He has feared to take on this load because of the hazard of interference with the continuous operation of the line. With a substation properly designed this fear on the part of the central station manager is not warranted.

In the past when the central station company attempted to finance the line and equipment and to serve at too low a rate this was an important matter. Now that the farmer finances the entire project it becomes possible for the central station manager to put in a type of equipment that will eliminate many of his past difficulties. He, therefore, desires an equipment which, while within reason as to cost to the farmer, will amply protect his lines and reduce service interruptions to a minimum.

REQUIREMENTS OF FARMERS' SUBSTATIONS

Now let us see what really are the factors which determine the design of a farmer's substation for it is this equipment that means much to the success of supplying electricity to the farm.

1. It must be inexpensive. This does not mean that it must be cheap.

2. While inexpensive it must perform all the functions of the larger outdoor substations with a reasonable factor of safety. It must have full switching, lightning protection and overload protecting features. It must operate with the same degree of security against service interruptions but in case of failure it must be disconnected at once from the line in order that the trouble might be localized and prohibited from disturbing the entire system.

3. It must be safe. There should be but very little wiring and it should be so arranged that when the switch is open all equipment is readily accessible.

4. The factor of safety of the insulators should be high.

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Line disturbances due to switching and action of fuses or oil circuit breakers usually manifest themselves at the switching equipment or at other points where the characteristics of the line change.

5. It must be neat in appearance. This is a factor often lost sight of by central station managers. These stations are often on the main highway or on the farmers' premises near his house. It must therefore not present a make-shift appearance.

NEW DESIGNS FOR FARM SUBSTATIONS

Realizing these requirements and the vast amount of work to be done in this field during 1920, the Delta-Star Electric Company, Chicago, Ill., has developed a type of station that meets the demand of the central station manager from an operating standpoint, and the farmers' pocketbook from a cost standpoint.

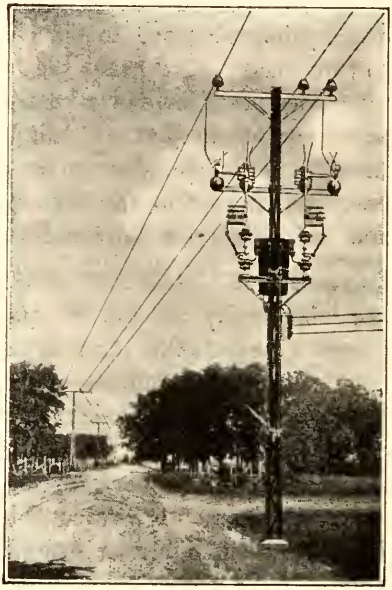


Fig. 1.
Typical Installation
High Tension Power and Lighting Equipment for Farm Lines.

A cut showing an installation of this equipment is shown by Fig. 1. Particular attention is called to the appearance of this equipment. This type of high tension single phase farm power and lighting equipment consists of a double pole switching, lightning arrester, choke coil and primary fusing element, complete with two steel cross arms and operating mechanism. These units are designed for mounting on a standard wood pole or on a standard steel pole as shown on the accompanying figures. The two single pole elements are provided with a mechanically interlocked operating mechanism. With this mechanism both blades of the primary switch are simultaneously opened and closed by means of a common handle located for convenient operation from the ground level.

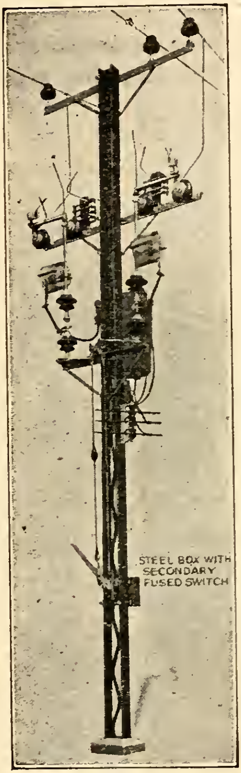


Fig. 2.
Switch in Closed Position

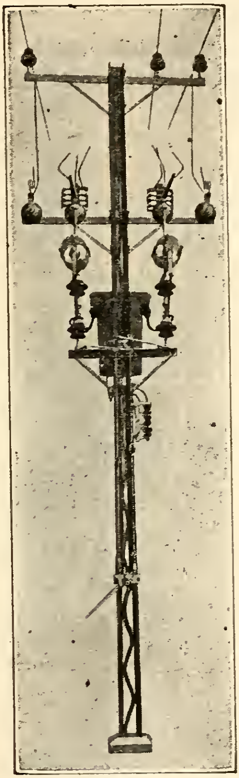


Fig. 3
Switch in Open Position

Enlarged views of equipment shown in Fig. 1. Note the position of the switch blades of the rotating elements as the latter as rotated 90 degrees by means of the remote controlled oprating mchanism.

Enlarged views of the complete substation are shown in Figures Nos. 2 and 3. A close-up view of this equipment is shown by Figure No. 4. Referring to Figure 4, each of the single phase elements consist of the following parts:

1. Switch insulator "A" mounted on a steel cross arm No. 1. This insulator is equipped with an auxiliary arcing horn and laminated spring phosphor bronze stationary contact so located that the rotating switch blade makes a wiping contact on the under side.

2. The steel cross arm No. 1, also carries insulator "B" which supports the "Line Side" horn of the lightning arrester. The "Ground Side" arrester horn and its limiting resistance are mounted directly on the steel cross arm No. 1. Should a resistance rod become damaged, it can be removed from its contact clips and replaced as easily as a blown fuse. To the cap of in-

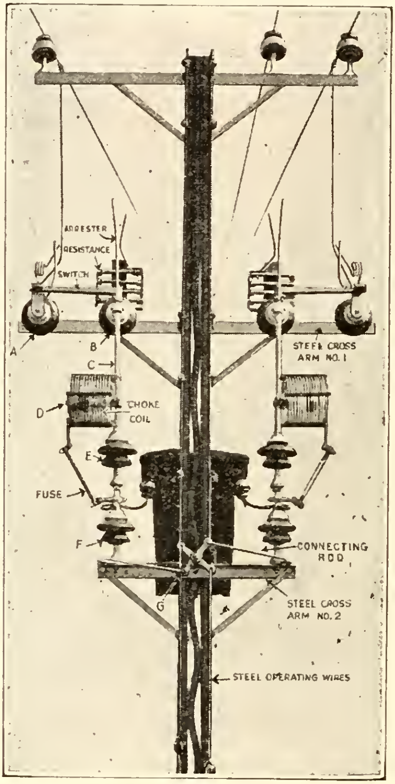


Fig. 4.
Close-up view of the High Tension Elements showing the parts in detail.

sulator "B" is rigidly fastened a lateral bearing for the rotating shaft "C" to which is clamped the adjustable switch blade. Proper contact between the fixed contact and rotating blade is easily secured as the blade is adjustable in a vertical and rotating position. After adjustment, the blade is held securely in position by heavy set screws.

3. Fastened at right angles to the rotating shaft "C" is an insulator "D"—to the cap of which is secured a fuse contact and one end of the choke coil, the other end of this coil being electrically connected to the rotating shaft. This choke coil is of the powerful long turn cylinder form type with re-inforcing strips and completely surrounds insulator "D."

4. Just below the long turn choke coil the shaft "C" is provided with an insulated section formed by insulator "E" to the pin of which is secured a fitting. One end of this fitting is provided with a flexible lead to which should be connected the transformer primary lead. The other end of this fitting has a fuse contact clip which with the contact on insulator "D" forms a mounting for the carbon-tetrachloride fuse.

5. Insulator "F" effectually jnsulates the entire element from gorund. Its pin in connection with the lower steel cross arm, No. 2, forms a lower bearing for the rotating shaft. The upper end of this shaft centers in the guide bearing attached to insulator "B." The path of current flow from the line is through the switch blade to the upper section of the insulated shaft, through the choke coil and primary fuse to the transformer lead.

90 *DEGREE ROTATION OF ELEMENTS*

Figure No. 2 shows the elements with switch blades in closed position; Figure No. 3 in open position. It will be noted that with this common shaft arrangement, the fuses, choke coils, switch blades and line side horns of the arresters all rotate 90 degrees—yet the movement of the transformer leads is extremely small.

As the line side of the arrester is attached to the rotating switch blade at the center of rotation, opening the blade automatically disconnects the arrester from the line—but without changing the length of the gap, thus permitting accurate measurement of the gap, safe adjustment and inspection.

The lower insulator pin of each rotating single pole element is provided with loop bearings in which are fitted horizontal steel rods connecting with opposite levers of the double bell crank casting "G." To the remaining levers of the double bell crank are fastened galvanized steel wires terminating at the operating handle. These wires are of the same type used for operating Railway Interlocking Signals, are strong and positive in action.

CLOSING AND OPENING PRIMARY SWITCH

To simultaneously close both switch blades the operating handle is raised and to open, it is lowered. By means of an ordinary padlock the handle can be locked in either position, see Figures Nos. 5 and 6. This primary switch arrangement is of importance from the standpoint of safety. For example, should a man after opening the switch be engaged in replacing primary fuses, the switch cannot close even though he has failed to lock the handle in closed position. Gravity holds the switch in open position and to close it the handle *must* be raised.

INSULATORS

In case of breakage, line insulators can be easily and quickly replaced whereas with the conventional type of switching or protecting equipment, changing the insulating support is usually a difficult, comparatively long and expensive operation. This equipment is furnished with "Unit type" interchangeable insulators making it possible to replace insulators with ease. Outside of accidental breakage there should be little chance of trouble. The insulators are designed so that they flash over before puncture and are derated so that they will take care of conditions far in excess of normal.

LOW TENSION FUSES

The 110 or 220 volt service line should be equipped with a standard switch with fuses of such capacity that they will blow at approximately 25 per cent overload. With this rating ordinary overloads will be taken care of and the fuses can be replaced easily by the farmer.

When desired, the secondary lines can be carried in conduit down to a steel box in which is mounted a fused switch as shown in Figure No. 2. This affords a convenient point for the farmer to cut off service from the house. If preferred, the secondary fused switch can be mounted at the house entrance or any other convenient general distribution point.

HIGH TENSION FUSES

The carbon-tetrachloride primary fuses supplied with this equipment are so rated in relation to the transformer capacity, that they will blow only in case of actual trouble, which is extremely rare.

Should a primary fuse blow it can be easily, quickly and safely replaced after lowering the switch operating handle and locking it in position. This operation opens both blades of the main switch, entirely disconnecting the equipment. Should the farmer neglect to lock the switch in open position it cannot close unless the handle is raised, as it is held open by gravity. It is therefore possible and entirely safe for the farmer to replace the primary fuse as it would often be impossible for linemen to reach installations for several days on account of bad roads.

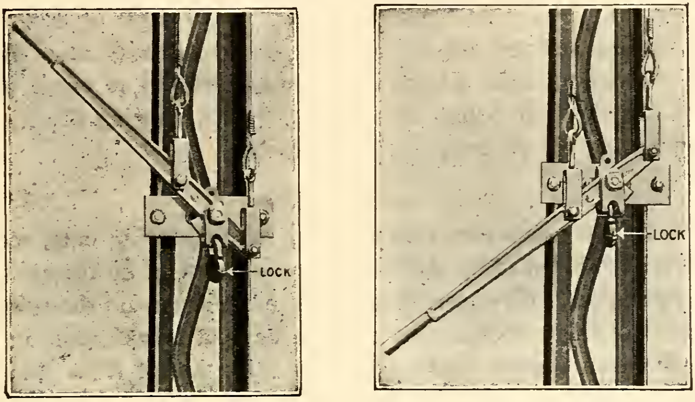


Fig. 5.
Closed Position

Fig. 6.
Open Position

Close-up views of operating handle showing the position of the handle and method of locking the mechanism when the switch is either in the open or closed position.

As mentioned above, some cantral station managers fear that trouble at one farmer's installation, such as transformer burnout, will communicate to the main feeder and interrupt service to other consumers. This point has been given careful consideration in the design of this equipment and resulted in the use of carbon-tetrachloride fuses for primary short circuit protection.

The only thing necessary to prevent the spreading of short circuit trouble to other points is to disconnect the defective transformer in such a short time interval that the circuit opening devices on the supply feeder will not have time to open. This opening action of the carbon-tetrachloride fuses under short circuit conditions is so rapid—(approx. 0.013 sec.) that short circuits at farmers' installations will be cleared approximately ten times faster than automatic breakers will open.

Too much emphasis cannot be placed on the necessity of using the carbon-tetrachloride fuse in installations of this character. A cheaper fuse could be used, but if farm lighting is to be made a success, trouble at the numerous transformer installations must not be allowed to communicate to or cause interruptions at other points of the line, thereby causing dissatisfaction among all of the other consumers.

METERING

With the equipment shown in the accompanying cuts, metering is accomplished by the installation of a meter on the consumer's premises. However, if it is desired to meter on the primary side it is only necessary to install a current transformer in one of the transformer leads, potential being taken from the secondary side of the power transformer.

If the metering is accomplished on the primary side the meter can be installed in an iron box immediately above the low tension switch and fuse box, or the two can be combined as they are in the later types of equipment made by meter box manufacturers.

GROUND DEVICE

This equipment can also be provided with an additional safety feature in the form of a grounding device. When the disconnecting switch blade of the unit is open, the grounding blade automatically and effectively grounds the entire unit.

THREE PHASE EQUIPMENT

For limited three phase capacity the equipment is the same as single phase except that three elements are employed instead of two. The units are interlocked and simultaneously operated by means of a common handle. These installations are well adapted for serving small towns from the farmers' transmission line or for supplying small amounts of three phase power to the farms.

CONCLUSION

To sum up we find that for the success of transmitted power to the farm, the following points should be considered:

1. The farmer should finance the entire installation, including line and sub-station equipment.

2. Rates should be so arranged as to eliminate all possible risks, even going to the extent of charging repairs and maintenance directly to the farmer and metering on the high tension side.

3. The voltage should be preferably 6600 or 13200 volts.

4. The main artery should be three phase, three wire, lateral extensions—metallic single phase.

5. All line construction should be adequate, safe and durable, so as to reduce the possibility of line failures with their consequent service interruptions and liability of injury to the public.

6. The substation must be inexpensive but at the same time have full switching, lighting and overload protection. All equipment should be easily accessible, have a high insulation factor of safety and should present a neat appearance—something that the farmer will be proud of and talk about.

7. Primary fuses should be rated about five times in excess of the transfarmer capacity; ordinary overloads should be taken care of by low tension fuses—rated about 25 per cent in excess of the transformer capacity.

ROAD ENGINEERING

By Raymond Zack, '11.

In view of the present magnitude of road building activities and the probable rapid extension in the near future it may not be amiss to point out in a brief and very general way the engineering work involved in the building of a first-class modern highway. These activities naturally fall under three headings.

1. Preliminary.
2. Construction.
3. Maintenance.

Under Preliminary comes all that part of the work up to letting the contract for construction.

Survey Party—After a certain piece of primary or inter-county road has been determined upon for approval, a survey party is sent out to make a careful survey of the road. This party establishes the alignment and takes cross-sections at every station or oftener where the road is rough. These cross-sections are later plotted up in the office and earth work quantities are figured therefrom. The matter of road alignment alone often calls for the very best judgment of good and capable engineers. In flat country of course the alignment will in all probability follow section lines, but in rougher portions of the state this is not always the case. It often happens that the road will have to be re-located in order to eliminate excessive grades, or too heavy earthwork, or a re-location may be desirable to improve the alignment of a bridge over some stream, or to eliminate a dangerous railroad crossing, or some sharp bend.

Location—When you stop to realize the heavy traffic some of our main roads already bear, and that this will be doubled, tripled and quadrupled after a road is paved, and that a paved road is put to stay, and further that in paving you are spending on an average of $50,000.00 per mile of road, then you see the necessity and the economy of spending time and money to get the best location it is possible to get.

Drainage—The field party making the survey is also required to take sufficient data so that a comprehensive drainage system both surface and subsurface, can be worked out for the road in question. Subsurface drainage has been heretofore somewhat neglected in road building, but engineers now begin to see the importance of having every foot of road in flat or clayey countries thoroughly drained out before any other work is started. A well drained soil is a stable soil and a poorly drained road will sag in summer and heave in winter, causing cracks and displacements in the paving. A road unequally drained—by that I mean one side drained better than the other—will cause unequal heaving and cracks in the pavement. The matter of drainage alone requires the best judgment and experience that can be brought to it.

Office Work—After a survey has been made the notes are sent into the office and the plans worked out. This consists mostly of detailing the topography along the road, plotting up the profile and cross-sections, laying the desired grades, computing all vertical curves and determining the approximate amount of earth required to bring the road to grade and standard section. All plans for the additional bridge work required are also gotten out at this time.

Construction Work—Building a pavement throughout the country districts brings its own engineering problems, which are different from ordinary city paving. The main problems are, of course, the getting of the material to and through the mixer in considerable quantities each day and also keeping up the water supply. The water supply alone amounts to quite an item, for it means usually a steam pump at some convenient stream, several miles of pipe line, a booster pump and more pipe line. Sometimes it is necessary to drive a good sized well 100 to 150 feet deep to get enough water. For in addition to the water used for mixing, the supply must also be sufficient for sprinkling and curing a concrete pavement. The sand, gravel and cement used are usually shipped in to some convenient siding and there unloaded from the cars by means of a clam-shell bucket, or other device. This shipping in of aggregates may be done in winter and the material piled up in huge stock piles and the cement in temporary storage sheds. Then after the paving work commences it is taken from these stock piles and by means of narrow gauge railways is transported to the mixer. Ordinarily, however, the material is unloaded from the cars into large bins and from these bins is loaded into trucks or narrow gauge cars in measured quantities and hauled to the mixer. Due to the fact that country paving is as a rule in the neighborhood of 18 feet wide, it lends itself very readily to being finished off by mechanical means, this saves labor and time and results in a first class job of concrete. To carry on a large country paving job and make good progress, calls for a heavy plant investment and an organization of a high order.

Maintenance—The maintenance of the roads is as yet in its infancy in the Central Western States. Some states have already made considerable effort along those lines, others are just organizing their maintenance department. One thing is certain: with the advent of high priced roads it becomes more and more important that an adequate system of maintenance be instituted to maintain these roads after they are once built. After the period of intense construction has passed, into which we are now entering, the maintenance of these roads will be one of the main functions of the State Highway Department.

This short article is not written with the idea of expounding new doctrines in building roads, but rather to call the attention of the young students in Civil Engineering to the many interesting engineering features in connection with country road work. Any technical magazine that you may pick up will tell you of the large amount of proposed work that is to come up in the next few years on country roads, to say nothing of the combined yardages of paving which is to be put in by the small country towns. The day of building roads by guess is gone. Every mile of proposed improvement is studied on its own merits. There is a great work to be done in the next few years along road building lines and it will require the services of the best men in the engineering profession.

THE ELECTRICAL INDUCTION FURNACE

By Walter M. Seyferlich, '20.

A.—ELECTRIC FURNACES IN GENERAL

An electric furnace is a device for transforming electrical energy into heat energy with the intention of effecting various chemical and physical changes in the material heated. It should be understood that the electric furnace is not primarily an electric device, but serves a definite purpose. As an example, take the case of the electric steel furnace, where certain materials are taken in a raw and unfinished state and are converted into a finished product having certain qualities that cannot be obtained either in the same quantity or at the same price in any other manner.

There is no specific feature between electric furnace reactions and those reactions which take place in ordinary chemical or metallurgical processes. The great distinguishing feature of the process is embodied in the apparatus itself, the heat required for the reaction being produced electrically. Thus, if the same amount of heat were generated in the same material in some other way than by electricity, the reactions would be exactly the same.

Although it has been known for many years that electrical energy may be converted or transformed into heat energy, the electric furnace as it appears today, is a comparatively recent development and is becoming more and more an indispensable factor in the manufacture and treating of many products.

This becomes evident when the widespread application of the electric furnace is considered, as in the production of aluminum, calcium carbide, carborundrum, artificial graphite and other artificial abrasives, that it is one of the great necessary elements in our civilization. It would be practically impossible to present in the space at our disposal a detailed description of all types of furnaces that have been used in the past, without considering those proposed, and hence the article below will treat only with the various types of electric furnaces based on the principle of induction, and particularly electro-magnetic induction.

In making an analysis of the energy required in the operation of an electric furnace, the energy per unit of mass is, in general, consumed in five different effects, as follows:

(1) To produce heat necessary to raise the starting materials to the temperature of the reaction.

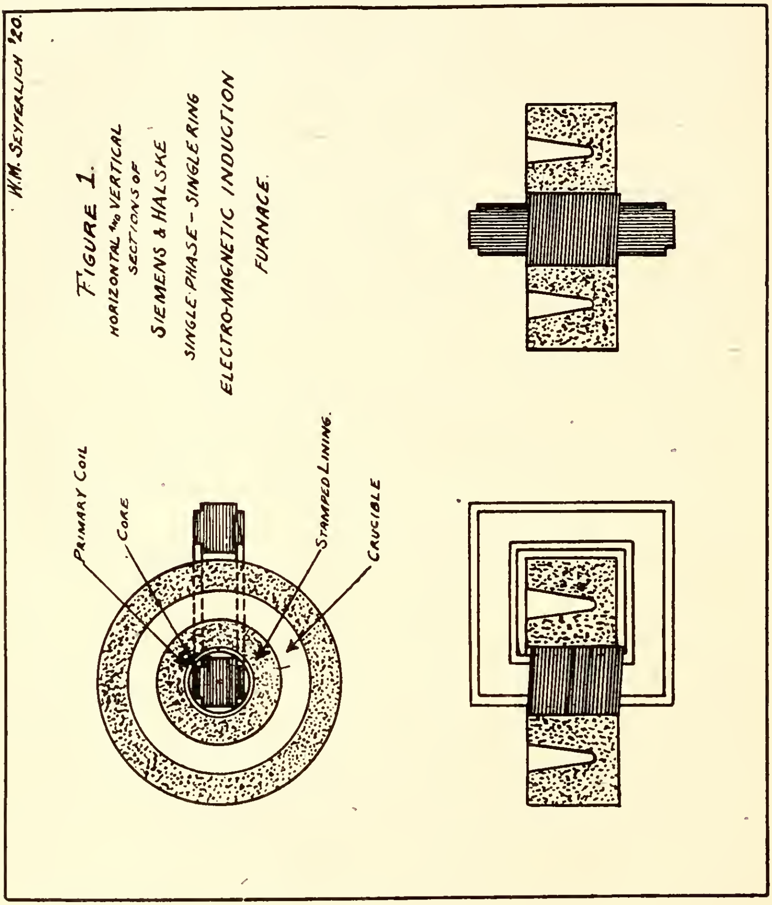


FIGURE 1.
HORIZONTAL AND VERTICAL SECTIONS OF
SIEMENS & HALSKE
SINGLE PHASE - SINGLE RING
ELECTRO-MAGNETIC INDUCTION
FURNACE.

(2) To provide the energy required for any change from solid state to liquid, from liquid to gas, or from solid to gas.

(3) To provide the energy for the chemical reaction.

(4) To provide the heat lost by conduction.

(5) To provide the heat lost by radiation.

I. To compute the heat necessary to raise the starting materials to operating temperature or the temperature of reaction, the weight of the charge should be multiplied by the temperature difference, and this product should be then multiplied by the mean specific heat. In order to reduce the amount of energy expended in this way, preheating by means of waste gases or other fuels are sometimes used. It is often of considerable advantage to divide the heating of the charge into two stages, one in which the lower ranges of temperature are obtained by burning fuel and only the higher ranges of temperatures being obtained fro melectrically produced heat.

II. To find the heat required for a physical change of the charge, as from solid to liquid, liquid to gas, or solid to gas, the weight of the charge should be multiplied by the latent heats. Wherever possible, this expenditure of energy should also be eliminated as in the case of electric steel refining, where the steel is preferably supplied to the electric furnace in the molten state from the open hearth furnace or Bessemer converter. If a gas be evolved from solid materials the work done in the expansion of the gas against atmospheric pressure must be taken into consideration also.

III. The energy required for the chemical reaction at the operating or reaction temperature, becomes an item of energy expenditure only if the reaction absorbs energy. However, the reaction may evolve energy, and in this case the additional energy should be added to that of the electric current and changed into useful heat, so that the amount of electrical energy to be supplied from the outside becomes less.

IV. The heat energy lost by conduction depends upon the difference of temperature inside the furnace and outside on the thermal conductivity of the furnace walls. In order to reduce this loss as much as possible, the furnace walls are built up of highly insulating refractory materials. In selecting these materials consideration should be given the heat insulating properties, the maximum temperature to which the materials are to be subjected, the chemical nature of the reactions for which the furnace is to be used and finally on the physical properties of the material with reference to expansion, extraction and mechanical stresses.

V. The loss of heat energy by radiation from the furnace walls to the surroundings bodies, may be computed according to the Stefan Boltzmann law and is proportional to the difference, $T^4 - T_o^4$, where T represents the absolute temperature of the outer surface of the furnace wall and T_o the absolute temperature of the surrounding medium. Although this law is strictly correct only for absolutely "black bodies," it may be applied to the case of a furnace surface for an approximate estimate.

In any and all types of electric furnaces the electrical energy is changed into heat energy by one of the following three ways: first, by producing an electric arc and thereby generating heat; second, by the Jonlean effect; and third a combination of the two types.

Accordingly electric furnaces are divided into three groups; namely, arc furnaces, resistance furnaces and combination furnaces. The material in a resistance furnace in which the electrical energy is converted into heat is called the resistor, so called because the electrical energy is transformed into heat energy on account of the electrical resistance of the path of the current. The rate of heating is directly proportional to I^2R watts or .238 I^2R g. cal. per second, where I is the effective value of the current in amperes in the case of alternating current, and R is the *resistance* in ohms (not reactance or impedance). In combination furnaces a superposition of two phenomenon is utilized.

In general, an electric furnace consists of a steel plate casing holding the refractory lining, mounted on rollers or trunions when designed for tilting service. The furnace is generally supported on rollers but other arrangements are used, such as supporting the furnace on trunions and tilting about an axis nearer the sprout which requires very little movement of the ladle.

Although all tilting furnaces for melting and refining and some stationary furnaces are fitted with closed tops, many furnaces, and especially those used for making few alloys are of the open-top type. Inside of the circular casing there is a brick lining which holds the stamped inner lining of fine material forming the hearth or bottom. Above the lining, are the side walls.

Where a basic lining is used the bricks are of magnesite or magnesium oxide, and the fine material of magnesite *or* dolomite

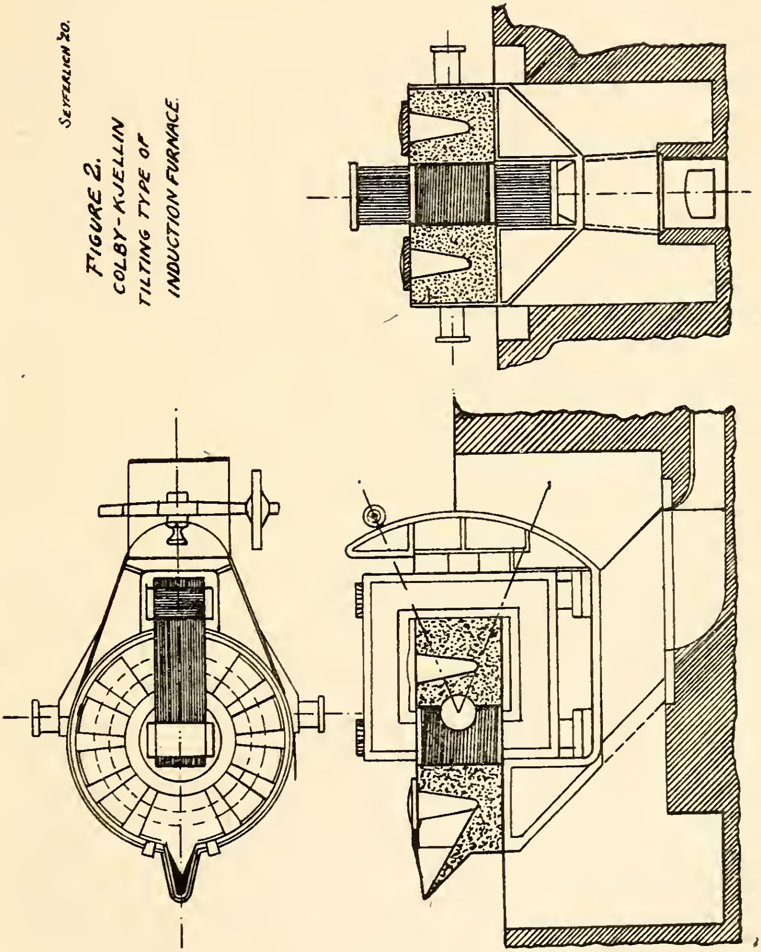


FIGURE 2.
COLBY-KJELLIN
TILTING TYPE OF
INDUCTION FURNACE.

SEYFERLICH '20.

(which is magnesite with varying percentages of lime, calcium oxide). Where an acid lining is used the bricks and fine material should be of silica, silicon oxide. In all cases the roof is generally of silica brick, although other materials have been used with success, such as ordinary fire brick or carborundum brick, etc.

As stated above, electric furnaces may be divided into three groups: the arc type, resistance type and a combination of the two. In all of these three types electrodes are required, except in the case of the induction type of resistance furnace, in which the current is induced in the charge itself. From this it becomes evident that the induction furnace cannot be started with ordinary scrap, but must have a closed metallic circuit in the hearth such as a ring of solid or molten metal. In the induction furnace, and, in fact, most resistance furnaces such as the graphite furnace, all of the heat is generated by passing the current through the charge. In other cases the heat is generated in resistors or arcs external to the charge, for example, resistance furnaces used for various kinds of heat treatments as the Stassano and Rennerfelt steel furnaces. In still other cases the heat is generated by current passing through arcs which are in contact with, or are buried in the charge, with some additional heat from current passing through the resistance of slag or charge. An example of such a furnace may be found in practically all the other electric steel furnaces, and furnaces for making ferro alloys, calcium carbide, aluminum, etc.

In general, furnaces may be divided into two classes: those used for smelting, and those used for melting and refining. Smelting furnaces are of the stationary or fixed type, while the melting and refining furnaces must be made of the tilting type. It becomes apparent, therefore, that for the same capacity, smelting furnaces are cheaper to build and require less attention for maintaining good physical condition than the tilting furnaces.

The standard rating of a furnace, of course, depends upon the service, such as the rating of a blast furnace at 450 tons, or ferro silicon and other smelting furnaces on a 24 hour continuous basis, while melting and refining furnaces like the open hearth, electric, bessemer, and tropenas furnaces are rated on holding capacity per heat, that is, 5 tons, 50 tons, etc. The rating of a typical induction furnace is shown below and it is very essential that the conditions under which this rating was given, be known and become indicated.

B.—THE ELECTRIC INDUCTION FURNACE

An electric furnace which is based on the principle of generating heat by electro-magnetic induction, or by induced currents, is called an induction furnace.

The type of induction furnace illustrated in figures 1 and 2, is essentially a transformer, the secondary of which is formed by a single turn or annealar ring made up of the charge of METAL, or other conducting material to be heated or fused.

This type of furnace is necessarily operated on alternating current supply which is transmitted to the primary winding, thus establishing an alternating magnetic flux in the laminated iron core. This alternating flux in turn, induces an alternating current in the secondary or furnace charge and an increase in temperature occurs due to the Jouleau I^2R effect.

The regulation of the heat produced is of greatest importance and is of course identical with regulation of the electric energy supply. In the operation of resistance furnaces such as the induction furnace itself, it should be understood that the resistance of the charge and circuit is a variable quantity during the run of the furnace, on account of the variation of temperature and also due to the chemical changes which may take place in the charge. It is advisable, therefore, that the maximum power available be supplied or used throughout the run of the furnace in order to work more economically. If the resistor be such that its resistance changes, provision should be made for proper voltage regulation, so that the maximum and minimum voltage attainable should bear to each other the ratio of the square root of the maximum and minimum resistance of the resistor.

If carbon is to be used as the resistor, it is advisable to raise it previously to the maximum temperature to which it is to be submitted in practice. Wherever possible it is better to use graphitized carbon, for that form of carbon is stable in its physical characteristics so that the only change that is undergone when using it as a resistor is temporary and due to the increase in temperature.

ARMOUR

The energy lost in the transfer from primary to secondary in the induction apparatus may be computed exactly as in the case of the ordinary transformed. The great difference between the induction furnace transformer arrangement and the commercial type of altenating current transformer lies in the fact that owing to the necessity of having the fused bath channel well insulated from the primary winding, there is considerable loss due to magnetic leakage.

Since the secondary resistance (metal to be fused) is very low, while its self-inductance it high, the reactance of that winding is comparatively high and hence the power factor of that winding is very low. The power factor is also reduced on account of the increase in leakage reactance over that in the ordinary transformer construnction, due to the wide separation of the primary and secondary windings.

However, the power factor may be improved considerably by decreasing the frequency of the impressed voltage, or increasing the ohmic resistance of the fused charge. Still another compensation for poor power factor may be effected by increasing the reluctance of the two magnetic leakage fields which would reduce the leakage reactance materially.

The greatest advantage in the induction furnace is effected by the elimination of electrodes, which as stated above are essentials in the operation of all electric furnaces except the induction furnace. It is through these electrodes or terminals that the electrical energy is introduced into the furnace or charge, and these represent the weakest point in the heat insulation.

The conduction of heat through an electrode is a more complicated phenomenon than the single heat conduction through the refractory wall. This is because there is a comparatively large difference in temperature between the two ends of the electrode, and each particle of the electrode is not only a conductor of heat energy, but also a seat of heat generation due to additional electrical energy conduction. Thus there is a superposition of two phenomenons; one single heat conduction from the end at highest temperature to that of lower; and the other, the generation of heat by the Jouleau effect within the eelctrode itself, this heat tending to distribute itself impartially, one-half to each end.

Elimination of the electrodes also means a great reduction in the cost of operation due to the fact that no electrodes are consumed, and at the same time roof troubles are greatly reduced. With no electrodes in the apparatus, the roof may be built closer to the metal, in this way diminishing the radiating surface and cutting down the cost of operation.

The cost and heat capacity of the lining are reduced materially for similar reasons and a great reduction is effected in the upkeep in this part of the furnace, which is ordinarily most difficult to maintain in good condition.

As compared with ordinary fuel burning furnaces the electric furnaces described have other advantages of import. First, a considerably higher temperature may be obtained and may be obtained in a relatively small interval of time. The temperature is limited in the arc furnace by the temperature of the arc which amounts to 3700 degrees absolute or about 3400 degrees centigrade, and in nearly all resistance furnaces chiefly by structural details, such as the insulating refractories available, etc. A peculiar limitation of temperature in the induction furnace and other resistance furnaces in which the charge itself forms the resistor is called "pinch phenomenon," and treats with the circulation and distribution of the heat energy throughout the furnace charge.

While temperatures up to 2000 degrees centigrade may be obtained in the ordinary chemical and metallurgical furnaces, it should be noted that temperatures up to 3500 degrees centigrade may be produced without any special difficulty in the electric furnace.

Also, for reactions requiring certain refinements, the electric furnace is especially adaptable in that it has the advantage of permitting easier control of the conditions of operation such as the temperature, the chemical nature of the atmosphere, etc. The chemical composition of the bath may be controlled absolutely by the careful selection of the proper raw materials, as the induction furnace has the additional feature of electrode elimination which prevents contamination in the bath.

Certain modifications of the simple induction furnace have been used in advantage in commercial practice, such as the Roechling-Rodenhauser combustion furnace. In this type of furnace the total heat is produced by a superposition of two heating effects, one according to the induction urinciple, and the other being produced in an auxiliary secondary circuit provided and arranged so that its ends are connected to metallic pole plates embedded in the furnace walls. The furnace is first heated by induction alone, and when the refractory layer which separates the pole plates from the metallic bath becomes heated sufficiently, it becomes an electric conductor and supplementary heat is produced by the electric current passing between the pole plates through the furnace charge.

The greatest advantages of this type of furnace over the simple induction furnace are that it can be used for refining as well as melting purposes, and that it can be built for ordinary commercial frequencies without lowering the power factor appreciably.

It might be thought at this time that such an arrangement as we have in the simple induction furnace illustrated in figures 1 and 2;—with a bath of molten steel at about 1500 degrees Centigrade and placed not more than 18 inches away from the winding that may be carrying current at a voltage of 2000 to 5000 volts, is very dangerous, and also, that extraordinary precautions must be taken to keep the coils cool. However, it has been found that this can be well taken care of by means of an air blast in the larger sizes or by using copper tubes cooled by water flowing through them as windings in the smaller furnaces.

Owing to the interaction between the heavy current in the bath and the flux, there is a rapid movement of the metal in a radial direction which tends to keep the temperature constant and assists in melting. The direction of flow is across the top of the channel to the inside, down the inner edge, and upon the outside edge. This motion becomes so great that the difference in level between the outside and inside, with a channel of 12 inches in width, may be 1 inch or more. These furnaces are reported to be in successful use in Germany and other parts of Europe up to 16 tons capacity and two such furnaces of 20 tons capacity each, are now in operation in Lebanon, Pa. The latter are rated as 20 ton single phase induction furnaces, taking 4000 KVA at 50 per cent power factor from a single phase 5 cycle generator. These furnaces have been operated very successfully.

Induced "eddy current" induction furnaces represent the latest development in that field and while this type of furnace is practically in the experimental stage, special efforts have been made to use various types of high frequency generators in conjunction with such a furnace. Since eddy-current loss appears in the form of heat energy in any conducting material, and since it varies directly as the square of the frequency, the application of a generator such as the Alexanderson type immediately suggests itself.

Frequencies of 2700 cycles have been used in set-ups of this kind and it is expected that such an arrangement should be adaptable an despecially suitable in certain phases of induction furnace work.

PROGRESS

Research leads to discovery, discovery to invention, invention to no one knows where. Applied and supervised by those prepared for the task, the strides of progress will be long and the benefits in proportion. Let us educate for living, certainly, but let us also educate for leadership—that superlative leadership of which civilization will stand more and more in need as it increases in complexity and reaches higher and higher planes.—(*Dr. William H. Nichols, President,* American Chemical Soc'))

* * *

THE STORAGE BATTERY

ITS VARIOUS USES AND ABUSES

By W. L. Borroughs, '15.

INTRODUCTION

A storage battery is like a watch—take care of it and it works fine; abuse it and it goes on strike.

Although storage batteries are used for hundreds of different purposes, and although they are used at practically every plant using direct current, the only battery that the general public and a great many engineers are familiar with, is the small starting and lighting battery used on automobiles. (See fig. 1.) This particular type of battery is used by more people and abused by more people than any other type of storage battery on the market and as a general rule, the first attention it receives is when it starts to give trouble and then, it is usually too late.

Care should be taken of the battery from the very start and the following are a few simple rules which should be strictly adhered to, in order to obtain satisfactory results from it.

Keep the solution in the cells always above the tops of the plates.

Add nothing but pure water.

Add water before a charge or immediately after starting a charge. (Water should be added about once a week.)

Never add acid to a cell, except in case solution has been spilled.

Filling plugs should be locked in place at all times, except when adding water or taking hydrometer readings.

Keep all parts of the battery clean.

1. *PERFORMANCE OF A STORAGE BATTERY*

A storage battery consists of one or more cells; each cell consists of positive and negative plates immersed in an electrolyte. The electrolyte of all lead storage batteries consists of a mixture of sulphuric acid and water in such proportion as to best meet the requirements of the service in which they are to be used. For the propulsion of locomotives, street trucks and so forth, the electrolyte has a specific gravity, as shown by the hydrometer, of approximately 1.270 to 1.280.

The voltage of each cell is approximately 2 volts on open circuit, but is higher than this when the battery is being charged and lower while being discharged. The nominal voltage of a battery is, therefore, the number of cells multiplied by two.

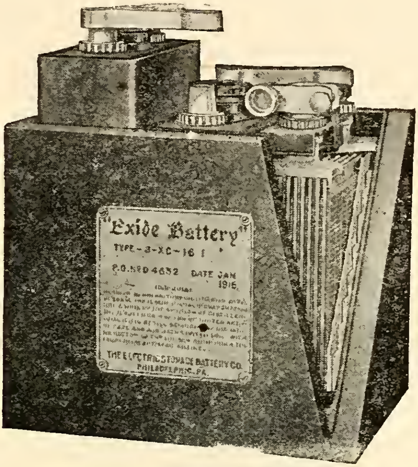
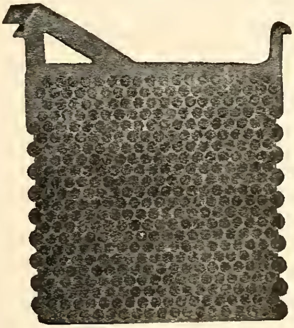


Fig. 1.

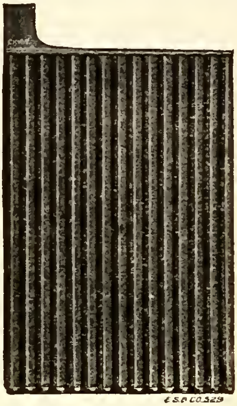
When a cell is being discharged the current is produced by the acid in the electrolyte combining with the active material of the plates. The active material of the positive plate is lead peroxide and that of the negative is metallic lead in a spongy form. When the acid combines with the active material, lead sulphate is formed in both the positive and negative plates. The sulphuric acid, which has been absorbed by the plates, has, of course,



"Manchester" Positive Plate.
Fig. 2.

been withdrawn from the electrolyte, with the result that the specific gravity of the electrolyte is reduced, and for a full discharge this drop in gravity will be from 100 to 125 points; thus, if the gravity of the fully charged cell is 1.275, the gravity at the end of a full discharge will be between 1.175 and 1.150, depending on the type of cell and the amount of the discharge.

To recharge the battery, direct current must be passed through the cells in a direction opposite to that of the current during discharge. This reversed current will revese the action which took place in these cells duing discharge. It will, therefore, withdraw the acid from the active material in the plates and restore it to the electrolyte. Thus, during the charge the electrolyte gradually becomes stronger as the acid is withdrawn from the plate until no more sulphate remains in the active material. All the acid having been returned to the electrolyte, it will be of the same strength as before the discharge, and the same acid will be ready to use over again during the next discharge, and the active material of the plate again in condition to combine with this acid.



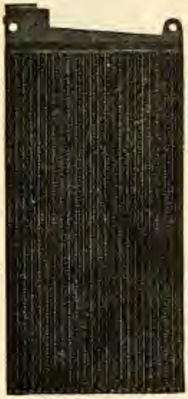
Type MV Positive Plate.
Fig. 3.

During discharge the action has simply been that of the active material of the plates combining with the acid of the electrolyte. The whole object of the charge is to again withdraw this acid from the active material and return it to the electrolyte. When all the acid has been withdrawn, the cells are fully charged.

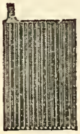
2. *STORAGE BATTERY PLATES*

Different battery installations require different types of plates and a different type of construction in general. The three principal types of plates used in present day storage batteries are the Plante or lead plate, the Faure or pasted plate, and the Ironclad-Exide plate.

The Plante plate is made from a lead plate having a large surface exposed and is formed by oxidizing the surface into lead peroxide either chemically or electro-chemically. This forms the positive plate, and by using these plates as cathodes and passing current thru them the hydrogen is liberated, reducing the peroxide to metallic-sponge lead.



"Ironclad" Positive Plate
Submarine.
Fig. 4.

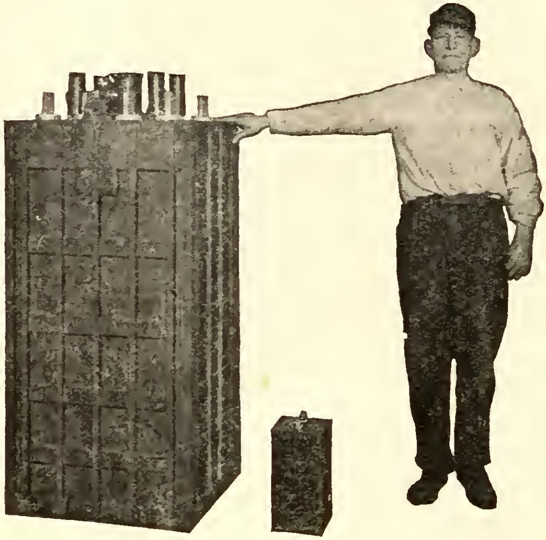


"Ironclad" Positive Plate
Vehicle.
Fig. 5.

The Faure plate is made by preparing a paste of lead peroxide for the positive and of lead for the negative and applying this paste to a lead-antimony grid.

The Ironclad-Exide plate is entirely different in construction from all other types of plates and is made exclusively by the Electric Storage Battery Company of Philadelphia. Hard rubber tubes about 3-8 of an inch in diameter are slipped over a lead-antimony pencil about 1-8 of anch in diameter and the space between the tube and the pencil is filled with the active material, lead peroxide. The tubes are finely slotted to give the electrolyte free access to the active material but are fine enough to prevent the active material from falling out of the tubes.

Each type of plate has its own distinct field. The Plante plate is a heavy plate capable of standing hard service and yet giving a long life. Due to the weight and amount of space occupied by a battery Plante plates, this particular type of plate is used principally in stationary batteries where frequent discharges are required; such as, telephone batteries and Central Station batteies.



Submarine Cell Vehicle Cell
Fig. 6. Fig. 7.

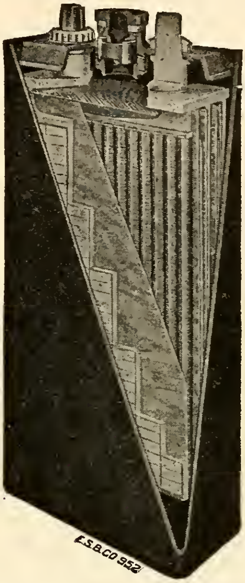
The Faure, or pasted plate is used where infrequent discharges are required; such as stand-by batteries in sub-stations, and is also used where the amount of available space is limited, as in automobile service, farm-lighting service, motorcycle service, etc.

The Ironclad-Exide plate, on account of its mechanical construction, is used in batteries where the space is limited but where hard service and fresuent discharges are required. The plate occupies slightly more space than the pasted plate, but far less space than the Plante. This type of plate is in service in practically all submarine batteries, in mine locomotives, industrial trucks and commercial street trucks.

Incidentally, a submarine battery consists of 120 cells giving 7200 Amps. at 220 volts for one hour, which will carry the submarine from 70 to 90 miles without charging. This battery weighs approximately 180 tons.

Figure 2 shows a Manchester positive plate which is a form of Plante plate, figure 3 shows an Ironclad plate, figures 4 and 5 show a comparison between a submarine Ironclad plate and a Vehicle Ironclad plate and figures 6 and 7 show a comparison between the corresponding cells. Figure 12 shows one of the applications of an Ironclad battery in an industrial truck, the truck being a Buda truck equipped with an electro-magnetic crane, both crane and truck being operated from the storage battery.

Fig. 8.



Type MVY-9 "Ironclad" Cell cut away to show construction.

A few of the principal places where storage batteries are used are:—

Central Stations, pleasure cars, commercial and industrial trucks, (Figs. 8 and 9) train lighting, farm lighting, railway switch and signal service, telephone service, submarine propulsion, drawbridge operation, yacht lighting, wireless service, aeroplane ignition and lighting, turret turning, sighting and firing of guns on warships and motorcycle lighting and ignition.

STORAGE BATTERIES IN CENTRAL STATION SERVICE

In the early application of the storage battery to central station service the primary object sought was the improvement of the daily load factor of the steam plant by discharging the battery on the evening peak and recharging it during the hours of lighter load. Under the conditions obtaining in many central lighting stations, this method of operation resulted and will today result, in a marked improvement in plant efficiency, since the total cost of producing a kilowatt hour of the peak is many times that for the same output developed under average conditions, when all the items, such as banked fires, extra labor and losses due to starting up and shutting down generating units for one or two hour's run, are taken into consideration. Where the peak is of short duration, the cost of battery is found to offset the cost of the steam installation which it replaces, leaving the improved economy as a clear gain. The advantage of the battery as a reservoir of energy, always ready for instant use in case of emergency, was always considered an important feature, but was formerly in many cases a secondary consideration upon which no definite value in dollars and cents was placed. It frequently occurred, however, that after the battery was put in service, this latter function proved so important and the continuity of service thus vouchsafed became so vital that the question of economy fell into the background,

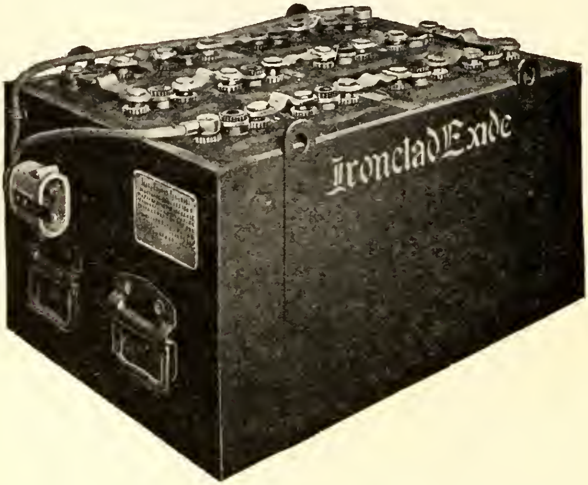


Fig. 9.
12-Cell "Ironclad-Exide" Battery for an industrial truck.

and the practice became more and more prevalent of holding the central station battery strictly in reserve to meet unexpected load conditions or derangement of generator apparatus rather than discharge it regularly on the daily peak.

The stand-by battey (see Fig. 11) in central station service is kept floating on the bus at all times except when charging. The number of cells connected to the bus is adjusted to give an average cell voltage of about 2.1—sufficient to keep a very small current flowing into the battery in the charge direction, to make up for losses and keep the battery fully charged. No automatic circuit breakers of any kind are interposed in the battery circuit. In some cases, however, remote control breakers are provided to permit opening the battery circuit from the switchboard by hand if desired.

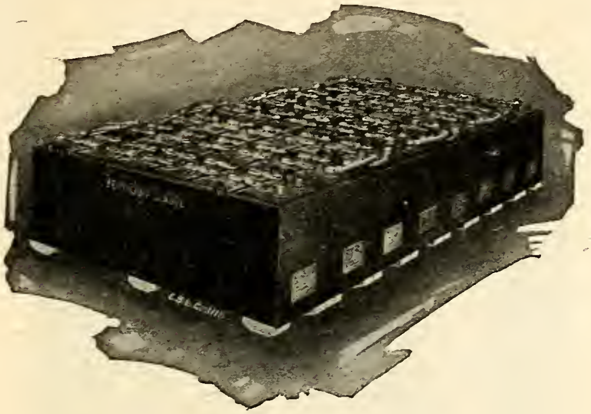


Fig. 10.

48-cell MVY-21 "Ironclad-Exide55 Battery for locomotive

The emergency conditions which call for a discharge of a stand-by battery include the folowing:

Interruption of power supply, due, for example, to low steam or to collection of ice in the forebay of a hydraulic generating plant.

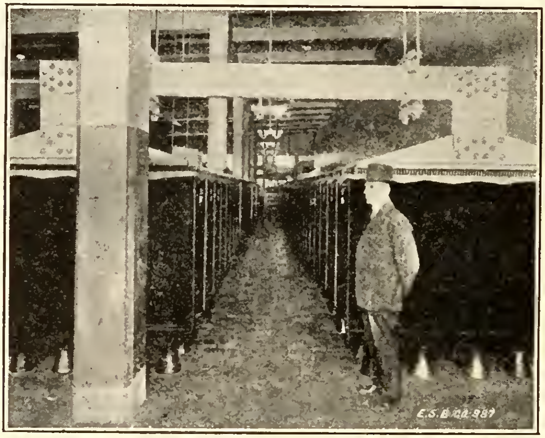
Break down of generating machinery, putting a portion of the generating capacity out of service.

Acidental opening of transmission lines due to short circuits, lightning, etc.

Unexpected increase of load, due, for example, to the sudden darkening preceding a thunder shower or snow flurry.

Short circuits in the direct current distribution network.

It is now standard central station practice to install a storage battery for stand-by service at each important direct current distribution center. Generally speaking, these direct current districts are located in the more congested sections of the city, while it has been common practice to employ alternating current distribution for the outlying and suburban districts where the average transmission distance from any given distribution center is considerably greater in proportion to the load. These alternating current distribution districts become, however, more and more important and demand a higher class of service with the increase of population density and the growth of local business centers, factories, places of amusement, etc. In many cases the importance of storage battery stand-by service for these alternating current centers is becoming more and more apparent and the use of storage battery installations for such service is now quite common, the storage battery furnishing the necessary direct current and also the required alternating current thru a motor generator set.



Fog. 11.

Emergency batteries are also used in connection oil switch opeation, station lighting and other auxilliary systems around the plant where continuity of service is absolutely necessary.

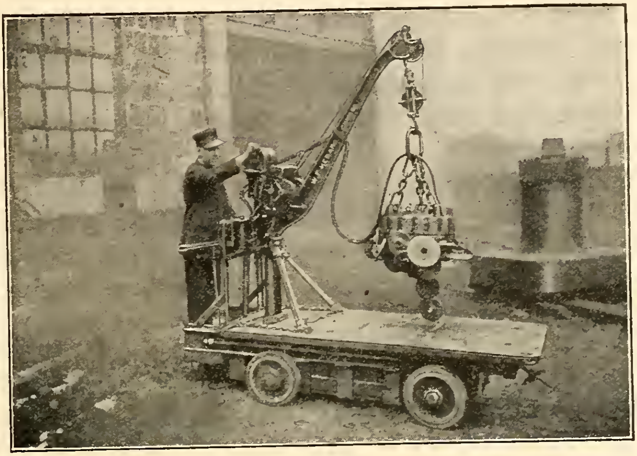


Fig. 12.—Buda Truck.

The Detroit Edison Co. have in service an Exide stand-by battery which is the largest one in the United States, having a capacity of aproximately 112,000 amps, for 14 minutes at 134 volts.

ARMOUR
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THE ABSORPTION OF AIR BY CHARCOAL AT REDUCED PRESSURES NEAR LIQUID AIR TEMPERATURES

By Thos. E. Doubt, Harry C. Thompson and H. H. Sheldon

(Abstractof a paper presented at the Chicago meeting of the American Physical Society, November 28, 1919.)

In the extraction of helium from natural gas and in other work of the War Department with charcoal, it was deemed very desirable to find out how air was absorbed by charcoal under reduced pressure.

The rate of absorption as well as the amount per gram of charcoal was sought. The results are given both in the form of curves and in tables. The measurements were made at 1-5, 1-10 and 1-20 of an atmosphere for temperature ranging from -160 to 193°C.

Thos. E. Doubt.

CHARCOAL ABSORPTION AND CYCLIC CHANGES

By Thos. E. Doubt

(Abstract of a paper presented at the St. Louis meeting of the American Physical Society, January 1, 1920.)

(This is a continuation of the work reported at the meeting of November, 1919.)

The absorption of gases as well as their evolution by activated charcoal are considered as processes in a cyclic operation. Data and curves are given. It is shown that the process is accurately reversible. Heat is evolved in absorption and required in evolution. Experiments have been carried out for the determination of the amount of heat involved.

The amount of work involved in the operation may be readily calculated from the data given. The laws of thermodynamics become applicable as well as the phase rule. The condition at any instant can be represented by an equation similar to that for a vapor.

We are glad to be able to publish these two abstracts of important phases of charcoal absorption presented by Prof. Thomas E. Doubt before the American Physical Society, and hope to be able to print the complete papers in a future issue.

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THE NEW ARMOUR INSTITUTE OF TECHNOLOGY

On February 21st the world was greeted with the newspaper announcement that The Armour Institute of Technology is to have a new home at 75th St. and Yates Ave. with a large campus and commodious buildings to house a maximum of one thousand students. This announcement was somewhat premature and was published by the newspapers before all of the details were ascertained, with the result that each paper printed a different story. The announcement as given out by Doctor Frank W. Gunsaulus, President of Armour Institute, covers the general plans for the new location and is given below.

"The Armour Institute of Technology, after twenty-five years of adjustment and re-adjustment to opportunities and conditions, has adopted its matured program of the future. It has received a substantial gift of land from Mr. J. Ogden Armour, so that it will at once inaugerate the development of its completed plans.

"The difficulty of obtaining a proper location within the City of Chicago has been great. Our problem has been to find and obtain title to a contiguous parcel of land, and it is now to improve it as a site upon which the institution may stand and progressively function as a center of engineering instruction and training. Its buildings and campus will occupy the entire eighty acres near the lake south of the South Shore Country Club, and formerly known as the Wentworth property. This tract has been more recently known as the grounds of the Windsor Park Golf Club. Having been purchased by Mr. Armour, it has just become the property of the Armour Institute of Technology.

"The authorities of the Institute have sought the advantage of a situation as easily approached as is this, by the city and suburban service of the Illinois Central and the Baltimore & Ohio railways. Near the north portion of the land obtained is the Windsor Park station of the Illinois Central which may be reached in a few minutes from downtown, when the railway and the Institute have completed their arrangements. The cross town electric lines at the north of the campus on 75th street are most convenient. On the south end of the campus at 79th street are electric lines connecting the west and southwest sides with our location satisfactorily. The Baltimore and Ohio almost touches the southwest corner of the eighty acres. The lake is within five hundred feet, and will furnish opportunity not only for water athletics, but hydraulic engineering and marine engineering, study and training in which must be undertaken in time. The ample land and water at our service could not have been more satisfactory for whatever may be judiciously done in military or naval training or shipbuilding. On the south are the great steel and cement plants of the Calumet District. These are not surpassed in the world for the uses of an institution whose students must visualize engineering processes in manufacture. Modern methods with us require visits to practical laboratories for the operative industries with which high grade engineering concerns itself.

"The tentative plans for our buildings and their arrangement constitute only a provisional study. The whole scheme which has been worked out after a quarter of a century of experience in the central west and in Chicago, means serviceableness in architecture as well as beauty and dignity. The buildings will constitute a piece of serious apparatus for the special work which any such institution must do at this time and in this region.

"Commodious as the buildings, and large as the location will be, the Armour Institute of Technology will limit its number of students to one thousand. The prospects at university foundations in Chicago and Illinois for the highest and most necessary research work in pure science are so large and secure that the Armour Institute of Technology will have only its responsibility in the central west for the training of engineers. The high schools of this region, especially the technical high schools, have their large responsibility in the preparation of students, who may expect in four years resident work at the Institute, after high school graduation, to receive our degree of Bachelor of Science in a chosen department of engineering. Our present methods so expanded and integrated, require large room for apparatus and for safety, as well as rigid adherence to a program of study and experiment under experts enabling the student to reach the ideal in view and so to meet the situation in American engineering. These problems are many and difficult. The world's coal problem must be solved by what is most necessary in America—namely—the use of our mighty and waste water power. The civil engineer must be ready to help make Chicago, Duluth, Detroit, and perhaps other cities serve as Atlantic ports. He must be trained to do his part in the future with those who have worked so excellently in the past to bring the lakes and the gulf together by the river system which nature has partially provided.

"When the Armour Institute of Technology emerged from the enterprise of a co-educational school and based its operations twenty years ago on the expectation of such events as the war which has come, it had no clearer vision, than it has now, of the necessities for engineering education of the highest grade in order that the larger problems of peace may be met and solved. It was a war of engineers when the battle was on, and American engineering greatly figured in winning the war. It is now a war of engineering against primitive and ignorant wastefulness of the forces of nature and the blundering of untrained men in economics and politics which creates the necessity for such education as we assume to offer. One thousand young men at a time being fitted for leadership in mind and skill will be our constant and tributary effort in the direction of a better-working civilization.

"In the matter of athletics, there will be abundant room for such games and athletic development as are not usually part of the physical training of American students. It is hoped to domesticate and enlarge the educational scope of many of our out-door sports on land and water, which have been foreign to students or impossible; first, because there was not land enough, or a great water-tract, and secondly, because of the too large portion of their time devoted to inside gymnastic exercises. The buildings planned at present will occupy about eight acres. A large portion of the north forty acres will be left for future developments. The south forty acres of the tract will be devoted to such sumer and winter out-door sports as will make out-door men supple and strong for their life work anywhere.

"Mr. Armour has studied the problem with the valuable help of other educators and managers of engineering enterprises. He found that the only solution is the inauguration of a foundation for technical training commensurate with the intention of the Armour friendship for such education. In any event, our city will be the greatest engineering city in the world, and Mr. Armour seeks to meet the opportunity and duty in the education of engineers."

THE ENGINEER AND THE PROFESSION

It has occurred to me that the engineer, although a member of the most important of all professions, has not assumed his rightful position as a pioneer, as an organizer, as a constructor. A clear recognition of this vital fact is especially imperative at this time. Analyzing the situation the following factors present themselves:

Engineering is applied science. What other line of study gives one such a keen and analytical sense? What other profession trains one to be so systematic and thorough? What, besides an engineering education, develops the habit of research and observation? The engineering student is trained to stand on the fact, to dig into the fundamentals of every problem and then to develop his solution, step by step, logically, without fault, and without equivocation. And with invaluable training what does the graduate student do?

He creates for himself a miniature world of office and home. He falls into the routine of this endless cycle and devolves into a clerk, a cog in a machine of his own design. He dissipates his education for want of initiative, and by the lack af perspective of his own true position. The position that he naturally inherits by virtue of his preparation is left vacant, as far as he is concerned, and thus filled by men, not with the training that our engineer has had, but with the training that he has not had, not in college but out of college.

These men, in their every day existence, develop a positive personality. They recognize the broadening influence of association, and in pursuit of this, they develop club, political and social life. Their sphere is in no wise limited and they enter upon all phases of the present every-day problems.

How often is the engineer found in politics, executively and judically? Read over the lists of men promoting and directing the promotion of new enterprises. Although a trained organizer and pioneer, the engineer does not often function, except as he is directed. On the other hand, I need only to cite Mr. Hoover as an engineer who has come into his own and successfully fulfilled the obligation to society imposed by his education. He is not building bridges nor designing steam engines, but he is applying his basic technical principles to construction that is just as vital. He recognizes that the aim of the profession is to advance civilization and render the highest service to society.

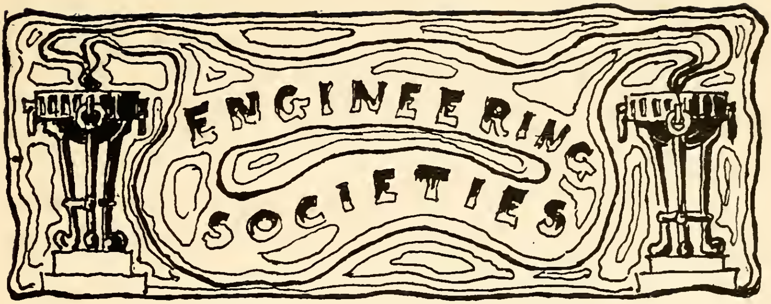
Because a man has studied chemistry should he close his eyes to all else and spend his days over a retort? Should a civil engineer do only that which is strictly civil engineering? The answer is obvious. Why, then, do we do this very thing? Because, as I have said, we disregard the influence of association, the services of the profession is not exploited; there is no unification or internal cooperation as in the Law or Medicine. The result is inadequate remuneration for technical services.

The Engineering News-Record of January 29th, states that the average compensation of the engineer is less than $2200 per annum, which is the estimated base cost of living for a moderately small family. Engineering & Contracting of December 24, 1919, says that the low price paid to engineers is not due to a great supply, for there is only one engineer per thousand population. The price is low because the demand is weak and the demand is weak because engineering has never been properly advertised and marketed.

What is the remedy? Broaden our circle of influence. Assume our civic duties in municipal, state and federal legislation. H. P. Gillette, a prominent engineer, has said that the engineers of this country can and will, eventually, be the prime movers in effecting a radical change in governmental management; that they are the only large body of men trained to apply science in the solution of economic problems.

This period of readjustment and reconstruction is the opportune time for the emancipation and evolution of the profession. There is an acute demand for technical service which is without precedent and with this will come just recognition if the technically trained will assert themselves, get out of the rut, and push themselves ahead.

W. G. WIGNALL, '20.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President	Ellis C. Cook
Vice-President	I. J. Bready
Treasurer	H. C. Peterson
Secretary	W. N. Erickson

The A. S. M. E. continuing its policy of calling on members for short talks and discussions have had some very interesting meetings of late. The meetings are still being held during the day instead of evenings and are being well attended. The following members—Mr. R. Regensburger, Mr. Sanger, Mr. F. Quinlan, Mr. Hoven, Mr. P. C. Gray, Mr. T. C. Sedgwick, Mr. M. Jackson and Mr. W. A.Heitner—have recently given talks to the society.

Mr. Regensburger talked adout and discussed the "Still" Engine. It is a combination gas and steam engine, being constructed by an English engineer by the name of Still.

Mr. Sanger spoke of a new form of gas turbine. Some of the ideas brought forth in this new type of gas turbine were entirely new.

ARMOUR
INSTITUTE OF TECHNOLOGY

Mr. Quinlan talked and described the method of testing the heat value of our city gas. Mr. Quinlan has had considerable experience in gas testing and hence knew his subject very well.

Mr. Hoven described a new type of motor-car suspension. Mr. Heitner talked about a new type of practical automobile tire pump.

Mr. Gray discussed motion picture machinery and motion pictures in general. Being experienced in this work, Mr. Gray gave a very interesting talk.

Mr. T. C. Sedgwick talked on rotary steam engines. He described different types of rotary steam engines and gave the Society a clear understanding of the relative values of the different types.

Mr. Jackson talked on a method of measuring the amount of air contained in an automobile tire. Mr. Jackkson also went into a lengthy discussion of the thermodynamic principles involved in his talk.

In conclusion, I wish to say that the A. S. M. E. is doing very good work this year.

William N. Erickson,
Secretary.

FRESHMAN AND SOPHOMORE BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President ....Jeff Corydon, Jr.
Vice-President ....'..........Otto Kuehn
Secretary ....G. Donald Wetherbee

The Junior section of the A. S. M. E. met February 27. The first part of the hour was occupied by a discussion of whether or not the society should have its pictures in the Cycle, and it was decided that it should, as it is now one of Armour Institute's recognized organizations. Participation in this picture will be limited to those who have attended at least one of the three meetings.

Mr. Corydon then talked about the application of engineering principles to salesmanship. It was a new thought and the discussion was very interesting, especially as this was the first talk we have had on a subject not purely engineering. Mr. Wetherbee then talked about powdered coal and the method of burning it.

All Sophomore and Freshman Mechanicals are urged to attend these meetings. It is worth their while.

G. Donald Wetherbee,
Secretary.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF ELECTRICAL ENGINEERS.

Chairman	W. M. Seyferlich
Secretary	H. D. Stevers
Treasurer	J. Smely

Several A. I. E. E. members took advantage of the opportunity of attending the meeting of the Chicago section of the Illuminating Engineering Society, held on February 19th at 7:30 p. m. in the Western Society of Engineers headquarters in the Monadnock building.

An interesting discussion on the "Essentials of Fixture Design" was presented by Mr. Ward Harrison, illuminating engineer and prominent authority for the National Lamp Works of Cleveland, Ohio.

Mr. Harrison, who has a very intimate knowledge of present and probable future developments in lamps, pointed out many important features of design for the special benefit of the representatives of the glassware, fixture and operating companies who were present.

As a matter of interest it may be said that "our own" Professor Freeman, who is one of the managers of the Chicago section of the Illuminating Engineering Society, urges all who can, and especially those who are interested in illumination or illuminating engineering, to attend the meetings and lectures held by that society.

It is the hope of the writer that all electrical students, and especially those who are members of the A. I. E. E., will from time to time give their special attention to the various bulletin boards throughout the school—those at the entrance to the electrical laboratory as well as those near the main entrance to the school—and in this way, become more familiar with the undertakings and meetings of the various societies.

Too much emphasis cannot be sounded on the importance of attending the meetings of these societies and the benefits derived by attending are such that they cannot be obtained elsewhere and are well worth obtaining.

The first regular business meeting of the A. I. E. E. for this semester was held on Thursday, February 26th, in the electrical lecture room. About twenty-five electricals were present and several of them filed application for membership to the national A. I. E. E. organization.

Announcement was made that the group picture of the local A. I. E. E. for this year's Cycle was to be taken at Bloom's Studio in the State-Lake building, on Sunday, February 29th, at 11 a. m. All electrical students and prospective members are invited to be present.

On Saturday evening a reception and dinner were given by the Western Society of Engineers, with the following societies as guests: Illinois Association, American Society of Civil Engineers, Chicago Sections, American Society of Mechanical Engineers; American Institute of Electrical Engineers, and American Institute of Mining and Metallurgical Engineers.

The dinner and reception took place in the Hotel Sherman banquet hall and was tendered Mr. Herbert Clarke Hoover, who was also recipient of the Washington ward for the year of 1919. The award was presented in the form of a metallic bronze tablet.

Mr. Frederick K. Copeland, president of the W. S. E., presided, while Mr. C. T. Loweth, chairman of the Washington Award Commission, made the official presentation; following which Mr. Hoover made an address. Many member of the above societies, some accompanied by friends, took part in the ceremonies.

THE ARMOUR BRANCH OF THE WESTERN SOCIETY OF ENGINEERS.

Monday, February 16, 1920, marked the beginning of a new fiscal year for the Armour Branch of the Western Society of Engineers. As the result of an eelction held two weeks previously, the following men were installed as officers for the new year:

R. M. Singer	*President*
G. C. Kumbera	*Vice-President*
G. W. Peterson	*Treasurer*
W. K. Lyon, Jr.	*Secretary*

W. T. Wignall, retiring president, gave an address on "The Engineer and the Profession"; a short summary of what the engineer means to the profession and vice-versa.

R. M. Singer, new president, gave a short talk on "The Purpose and Aims and an Engineering Society," a concise statement of what an engineering society should be and its methods of procedure.

At a later date the interest of the Society was held by a talk on "Unforseen Problems in Building Construction," by Derwood S. Chase. Mr. Chase recently returned to school after chasing the Heinies and serving as superintendent of construction for a large Minneapolis concern. The talk ended in a general discussion by the members. Roy M. Singer promises to continue the discussion at the next meeting by telling us of a few of his experiences in the wrecking business.

The last report stated that we expected to enlarge our membership lists. We have. Forty-one men are now enrolled on our books and we are boosting for more.

Each man now carries a card furnished by the W. S. E. certifying his membership and we have promise of receiving badges soon.

Last year, under the excellent leadership provided, was a very successful one and we expect to enjoy even a better period, if possible, during this fiscal year.

William K. Lyon, Jr.

THE CHEMICAL SOCIETY
OF
THE ARMOUR INSTITUTE OF TECHNOLOGY

E. G. Vogt	*President*
E. G. Winter	*Vice-President*
W. J. Bentley	*Secertary*
P. L. Stern	*Treasurer*

On February 13, the Society had the pleasure of hearing Dr. Eisenschimil talk on "The Business Prospects of the Young Chemist." On March 4th, Mr. R. E. Coleman of the Essenkay Products Co., will address the meeting on "Colloid Chemistry and its Application in the Industries." It is the intention of the Society to hold bi-monthly meetings and the officers will welcome the suggestion of desirable speakers by the members.

Dr. Eisenschimil gave a brief review of his professional experiences from routine chemist for a Pittsburgh Steel Works to the position of millionaire executive. He believes that graduates often fail by accepting too low a salary to start with, and counsels "poker tactics," and then the endeavor "to deliver the goods." His motto is: "Give good service and charge enough to command respect for your services."

His diagnosis of the case of the poorly paid chemist is as follows: The chemist, and chemical engineer, has come to be regarded by the business world as an employe holding a job and not as a professional man holding a position. He is rated somewhere below a skilled mechanic and is expected to take orders from everyone down to the office-boy. In place of a mere routine worker, the chemist should demand a share in the executive life of the plant and not be content to let others initiate and direct operations. Otherwise his position is hopeless. He does the vital work and lets others use his results and profit by them, for it is the executive responsible for the final product who is rewarded. To achieve this, he should prepare himself along business lines, become conversant with the methods of modern business and strive for the judgment and viewpoint of the business man.

Like most successful men, he has tended to the extreme in one direction—in this case the lack of appreciation of a technical education. Dr. Eisenschimil claims that the young man who enters the business world from high school will make more of a monetary success than the college graduate. He admits the desirability of a college course but thinks the loss of four years experience an overbalancing detriment. In this we think he is wrong. His mental alertness and broader and more comprehensive viewpoint will prove to be Seven League Boots. He can readily supplement his professionary training with a knowledge of business methods and far outdistance his untrained competitor. Without wishing to be presumptous, we would like to present this side of the case to the careful attention of any who may have heard the talk.

However, Dr. Eisenschimil's speech contained many valuable suggestions and was greatly appreciated by all the members. It was so original, human and free from pedantry that it was a privilege to have been present. We only hope that the future lectures will be as pleasang and instructive as this one.

—W. J. Bentley.
Secretary.

ARMOUR RADIO ASSOCIATION

H. D. Stevers	*President*
V. L. Cooley	*Vice-President*
A. R. Mehrhof	*Chief Operator*
R. J. Grant	*Secretary*

During the past month, radio affairs at Armour have taken on a bright aspect. The construction work on the station is well under way; in fact one phase of the undertaking, the short wave set, is practically complete.

After careful deliberation and many difficulties surmounted, it was decided to locate the station proper on the second floor of Chapin Hall. The short-wave antenna is fixed above the building, extending from the dome of the Mission to a twenty-five foot mast on Chapin Hall. It is of four-wire spread and is designed for short wave reception and transmission. Of simple, sturdy appearance, yet its scenic beauty enhances the picturesqueness of the surroundings. The transmitting apparatus consists of a 1 k.w. rotary converter, a 1 k.w. transformer, rotary spark gap and usual accessories. It is purposed to install also, an undamped transmitting outfit in the near future, so as to permit the operation of a radio telephone. The receiving apparatus uses a valve detector and a three-step amplifying circuit. The set is arranged on a panel in accordance with the best commercial practise.

Also, a much larger antennae has been designed, but, as yet, has not been erected. This is to consist of but one strand of wire, six hundred feet long, extending from roof to roof over the adjacent buildings. Being for receiving purposes only, it has a high fundamental wave length; by its use, it is expected to receive the more distant, high wave-length stations with comparative ease.

The construction work will probably be completed in another month, providing sufficient raw material is available on the market. The A. R. A. will then begin to take its first strides forward in the field of science and research.

Richard J. Grant.

THE ALUMNUS

Being that part of **The Armour Engineer** devoted to personal mention of the Graduates of the Aromur Institute of Technology and to the affairs of the Armour Alumni Association.

Communications should be addressed to John J. Schommer, 33rd and Federal Streets, Chicago, Ill.

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This is the kind of co-operation which we like to receive.

* * *

Office of the Vice-President and Secretary.
April 2nd, 1920.

Dear Sir:

"In looking over the January number of the Armour Engineer, I notice you are in need of addresses of a great number of the Alumnus. I wish to place you in touch with two of the men whose addresses you desire.

"Mr. L. N. Bexten, '09, Instructor in Chemistry, Omaha High School, Omaha, Nebr. Mr. G. M. Hemsen, '07, is Engineer at the Fairmont Creamery Co., Omaha, Nebr.

Very truly yours,
Sidney C. Singer,
Omaha Gas Company,
1509 Howard St., Omaha, Nebr.

COLLEGE NOTES

On December 12, 1919, the Tech Basketball Team played its initial game with the Hillsdale College, and thereafter participating in several practice games with local institutions. Mr. Volz, the college coach, had molded into proper shape a most formidable team, preparatory to the following schedule:

Hillsdale College	Dec. 12, 1919,	at Armour
Monmouth College	Dec. 19, 1919,	at Monmouth, Ill.
Valparaiso University	Jan. 3, 1920,	at Valparaiso, Ind.
Monmouth College	Jan. 9, 1920,	at Armour
Valparaiso University	Jan. 12, 1920,	at Armour
Wheaton College	Jan. 14, 1920,	at Armour
Lake Forest College	Jan. 23, 1920,	at Armour
Augustana College	Jan. 30, 1920,	at Rock Island, Ill.
Northwestern College	Feb. 3, 1920,	at Naperville, Ill.
Gary Works Ass'n	Feb. 14, 1920,	at Gary, Ind.
Illinois Athletic Club	Feb. 19, 1920,	at Illinois Athletic Club
Northwestern College	Feb. 26, 1920,	at Armour
Hillsdale College	Feb. 27, 1920,	at Hillsdale, Mich.
University of Detroit	Feb. 28, 1920,	at Detroit, Mich.
Lake Forest College	Mar. 2, 1920,	at Lake Forest, Ill.
Chicago Technical Col.	Mar. 2, 1920,	at Armour
Concordia College	Mar. 13, 1920,	at Ft. Wayne, Ind.

The Tech Team competed with the forerunners of basketball, and had proved its mettle throughout the entire tournament. When our players had met with the University of Detroit, and the Hillsdale College, the fact that both of these were the almost invincible champions of the state of Michigan, had no effect to curtail their careful and scientific playing. The score in the Detroit game was an even balance of 12 to 12 in the first half, and 20 to 20 in the second; the opposing team rang up a few baskets in the final three minutes of the contest. This, of course, tipped the scale against us. Brady sank three baskets, and four free throws, while Erickson followed close behind him with an equal number of points. The result as registered was 32 to 20, in favor of Detroit University.

Early in the season our boys had been driven through rough and rugged practice for their game wtih the Illinois Athletic Club. It need not be said that this aggregation is reputed to be Chicago's finest. The Tech players were in their respective places prepared to meet the I. A. C.'s offensive drive. Bready spurted about the floor like wildfire. Sacks, the I. A. C. guard, was taken by surprise when Ira punctured their baskets with a volley of shots, which, if Old King Luck had been with him, would have carried Armour's score to the sky. Ira started out with four baskets in the first half of the game, and finished with four points. Schumacher was sent into the game shortly before the end of the second half. Kuehn started the game as forward, and sank a basket right off the bat. Ahlbeck replaced Kuehn, adding another basket to the Tech score. Erickson played a hard game. "Bill' rang two baskets in the second half of the game, both cutting clean through the gap. May withstood many slams and bangs against the I. A. C. apparatus about the walls, and tearing through the lines wtih high celerity, our Big Boy just dropped one in for good luck. Havlick did likewise. The score resulted in our opponent's favor at the rate of 33 to 26.

These two leading games having been satisfactorily disposed of, the remaining schedule was pursued with much success. Basketball this season has had a large following. The general student body of the Institute looked to the Tech Team to snow under each of its opponents. The gymnasium had never before been visited by such a great number of basketball enthusiasts as attended the games this year. An unusually strong feeling of school loyalty was clearly manifested by those who looked on. Instead of open spaces in the gymnasium, this season's basketball attracted most of the general student body, filling these places with Armour loyalists.

A basketball tournament cannot be carried on successfully in the absence of scholastic support. In all colleges where basketball is paramount, as a recreational study, it invariably happens that only those directly or indirectly connected with the team are sufficiently interested in its accomplishments. It is a serious situation with which all colleges must cope. No tangible means are at hand for its cure. Too few people realize the incalculable amount of human energy that needs to be used up while a game is in progress. A player's health and limb are jeopardized every moment of the game in which he participates, and the wounds that are inflicted upon him are of a character not incidental to other kinds of sport. A basketball player who receives a deep cut in the face, or is precipitated to the floor with such force that he is unable to continue playing that game, or any other games, should stand out as a sound reason why all, not only a few, of the great student body of any educational institution should rally to his support. An injured player's pain is not half as serious as the lack of athletic spirit among the students.

A bleeding nose, or a floor burn, may be given first aid, but there is no remedy for a persistency among college men to disregard the activities of their various athletic organizations.

The basketball season this year has been a most successful one. Unlike former years, many had answered the call of their conscience to stand by and stick with the Tech Team. The fact that this change in local centers had taken place, aided materially in hoisting our colors of victory to the top. Our team fought mightily to defeat each of its opponents, and in the course of playing succeeded in conquering almost all of the matches with most of the Little Five aggregations.

A baseball schedule is now being formulated. The writer earnestly urges all of the students of the Institute to attend these games, which will be held in Ogden Field. It may be anticipated that the baseball season will terminate in the same successful manner as that in basketball, if all of the student body will boost and support the team.

We are indeed proud of our athletic traditions! They have descended to us from years gone by. Let us preserve and uphold those precedents established for us by our predecessors.

SENIOR ELECTRIAL GRADUATES FOR 1920 and THESIS SELECTIONS, BY GROUPS

A. R. Throop (completed with E. H. Arnold, '19)—Subject: "The Use of Vacuum Tubes in a System of Multiple Telephony"

E. Scheuer (completed with R. Joslyn, M. Veremis and H. F. Geldmeier of 1919)—Subject: "Special Advanced Dynamo Experimentation."

R. D. Morgan—"An Automatic Telephone System."

H. D. Stevers—"Design and Construction of Radio Station for the Armour Institute of Technology."

J. P. Muelleman and J. Simely—"Surges and Transient Current Phenomena, and Protective and Compensating Devices for Same."

A. Sugarman and A. Q. Grant—"Design of a 15,500 k.w. Steam-Electric Power Plant."

Renaud and S. Bloomberg—"Design of an A. C. Generator."

W. M. Seyferlich—"Development of a New Electric Anemometer."

ALPHABETICAL INDEX OF ADVERTISERS.

	Page
Armour Institute of Technology	1
Armour & Co.	9
Banning & Banning	6
Brady Foundry Co.	4
Chas. H. Besley & Co.	3
Clarke-McElroy Publishing Co.	11
Estes Incorporated, L. V.	3
General Electric Co.	2
Hansell-Elcock Co.	8
Hills, Chas W.	8
Jointless Fire Brick Co.	7
Koehne Studio	10
Leschen & Sons Rope Co.	6
Lufkin Rule Co.	3
Magie Bros.	8
Roebling & Sons Co., John A.	5
Swenson Evaporator Co.	6

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and
Wm. N. Erickson

The Armour Engineer

VOLUME XI MAY, 1920 No. 4

FACTORS INVOLVED IN THE DEVELOPMENT OF A NEW ORGANIC CHEMICAL PROCESS.

C. C. HERITAGE, '14

Many papers have been published since the war, dealing at great length in an abstract manner with the future of the American Chemical Industry, its opportunities, importance and responsibilities, also its accomplishments. That the opportunities and responsibilities are vast and the accomplishments small, relatively speaking, those who have gone through the melee of the last five years in the organic chemical industry can well attest. Orderly development is now making itself manifest and one of the fields in which this is of paramount importance is in the development of processes for the manufacture of new products, new being used strictly as regards the line of the particular manufacturer in question.

In this discussion it is assumed that the concern is of sufficient size to maintain separate Research, Engineering and Manufacturing departments and that the Research Department recognizes the necessity of employing, and the proper functioning of the Chemical Engineer as well as the Chemist.

There are four stages through which an organic process should go from the time of its inception as a laboratory problem to the time when full scale factory production is an accomplished fact. These we shall designate: Laboratry, Semi-Technical, Technical and Full Scale.

During the first of these stages the responsibility should be entirely with the organic chemist, although the cooperation of the chemical engineer is helpful even in this initial work when a choice is to be made between methods or reagents which affect design or operation of full scale equipment. In other words it is often simpler to adapt procedure to apparatus rather than vice versa. And this "plant sense," judgment as to what constitutes a practical plant process, is something which can neither be taught in colleges nor acquired in a fortnight in the plant.

As the laboratry stage nears completion, one of the chemical engineering staff should be assigned to work under the organic chemist, actually performing in detail the laboratory process.

Before the second stage, or semi-technical work can be begun, a report by the Organic Chemist should be available presenting the following data:

1. A complete bibliography with abstracts presenting especially the various methods by which the reaction may be carried out. Factors entirely outside the chemistry of the process, for example, availability of raw material, may at a later date completely change the situation.

2. A discussion of raw materials used. Specifications covering both physical and chemical properties should be given in detail. The heavy chemicals should not be slighted because certain well defined grades are on the market and the specifications well known. Nitrous acid in 66° sulphuric causes a great deal of trouble. Variation even in the water content of 88-92 caustic potash affects the yield in potash fusions to a marked degree. Common salt present in a certain domestic soda nitrite introduced a variable unknown at the time which caused no end of trouble and expense until located. It is therefore well to investigate the various possible sources from which the desired raw material may be had and choose that source which would seem to offer the least objectionable impurities. Synthetic nitrite and acetic acid are much to be preferred to the old products. The necessity for strict specifications covering the purity of organic chemicals particularly the intermediate or basic material entering the process cannot possibly be over emphasized. The technical organic intermediates imported into this country from Germany prior to the war were without exception of excellent purity. Specifications are unsatisfactory without definite proven methods of analysis and these should be included in the discussion of raw materials. Methods based entirely on physical properties are many times misleading and should never be used unless a com-

plete research has been conducted by a competent physical chemist. The melting point is used probably more than any other physical property and unless the complete melting point diagram is known, the measurement really means nothing. Analytical methods based on definite chemical reactions proven to be quantitative in the presence of all possible impurities, should be the ultimate goal.

Any purification of raw materials necessary prior to processing should be discussed, for in the present state of the industry it is sometimes impossible to obtain materials of sufficient purity to immediately enter the process.

3. A clear yet concise statement of the chemistry involved.

The directions with quantities expressed both as actual weights and as molecular proportions involving writing the chemical reaction, should be presented if possible. Considerable judgment must be exercised as to what constitutes a feasible plant procedure. Such general propositions as excessive purification, extremely corrosive conditions, strongly acid or alkaline filtrations especially hot, organic solvents with complicated recoveries, the handling of emulsions or tarry viscous solutions or suspensions should be avoided if possible. The engineering involved may not be necessarily difficult but conditions such as the above tend to increase the cost of manufacture often unnecessarily.

The variables involved, both physical and chemical, with the effects of each upon the yield and quality of the product should be covered completely. This information is best presented by the use of such curves as time-yield, temperature yield, time quality, temperature quality, etc. Tht optimum conditions then become obvious to anyone.

In order to secure the data necessary to present the above, accurate methods of control are necessary. These are then available when further development to a larger scale necessitates a change in the time cycle which very often obtain in technical scale work.

Control methods may or may not be based upon determining the amount of finished product present at any time. Examples of the simpler control methods used which do not involve a determination of the finished product are: estimation of fixed ammonia formed in the conversion of amine to hydroxyl, and estimation of sulfite when sulfonic is converted to hydroxyl. For purposes of research tedious quantitative methods must often be used. These are later simplified for plant use or merely qualitative methods may be employed, provided the quantitative and qualitative results have been shown to be properly interrelated.

The coupling of a diazo body with a phenol is usually controlled merely by spotting the reaction mixture on filter paper and testing in the ring for the phenol with more diazo solution or for the diazo body with more phenol.

It is of first importance that an accurate method of analysis be available even during the laboratory work by means of which the purity of the finished product may be estimated. Yields have often been expressed in the literature as "so much product from so much raw material," in other words nothing more than a crude weight yield. A great quantity of information on organic reactions has been developed in the past in this manner and it would not be true to say that these data are of doubtful value. But in the present state of the science, there is no excuse for this practice either in the laboratory or plant. Yields should be expressed as percentage of chemical theory, and in order to calculate this figure the quantity of pure raw material and pure finished product must be known. Analytical methods may be based upon physical properties such as color, melting point, solubility, etc., or upon a chemical reaction. The latter is to be preferred. Securing a satisfactory method in the organic field is often rendered difficult by the presence of isomers or of compounds having two of the same substituent groups in the molecule as against one in the desired product or vice versa. The results from a certain process had shown about 60 per cent of theory for a considerable time and every effort was made to secure condtions which would increase this yield. The trouble was finally located in the matter of purity of the intermediate used as a raw material. This had entered into the calculations at a purity of about 90 per cent. It was finally found that the purity was 70 per cent, the remaining 20 per cent being a disubstituent body of no value in the reaction. The true percentage of chemical theory had been then about 80 per cent rather than 60, and although the chemistry of the process had not been improved by this finding the necessity for further intensive research had been obviated.

By-products should have been investigated to the extent of determining their commercial value and if possible, should be produced in such form that they may be re-used in the same plant without contact with the sales department. As an example, potash fusion liquors may be cheaply converted to several different potash salts and as such re-used in some other process.

Waste products are often offensive and means for the disposal of such are necessary before semi-technical work is begun.

4. Certain observations, bearing on the engineering side of the problem are often made during the laboratory work.

Materials of construction may be tested in the reaction mixture and corrosion noted or if the reaction is carried on under pressure a satisfactory material of construction must be found during the laboratory work, though this material may not ultimately used in the plant. Satisfactory filter media will also come under the observation of the laboratory chemist during his work.

The hazards involved are usually fairly well defined before the semi-technical scale of work is reached. These may be either fire (explosion), or physiological in nature. The former may be due to the combustible or explosive nature of the raw materials, or to the reaction itcelf. In any case, correct engineering practise greatly minimizes the danger as pointed out farther on.

5. A calculation of the chemical cost of the product is, of course, the ultimate test of the thoroughness of the laboratory work and the feasibility of further development of the project. Costs should be calculated on a basis of both pre-war and present prices. The former may be compared with known pre-war figures for the same finished product and fairly accurate conclusions drawn as to whether the process in question may compete under normal conditions, should these ever return. A fair present selling price may be obtained by knowing the labor, repair and overhead charges on similar operations already on full scale production.

This laboratory report having been accepted and further work authorized, semi-technical scale study may be begun. This involves primarily the duplication of previous chemical results and secondarily the beginning of the engineering work, and should be carried out jointly by the chemical engineering staff and the chemist who directed the laboratory work. The product should be made in relatively small amounts, say from 10 to 25 lb. batches, inasmuch as larger quantities usually entail needlessly expensive losses. The equipment is all small but it is very important that the units should type miniatures of the same materials of construction as those to be used in full scale manufacture. Such pieces of apparatus as a No. 1 "Sweetland" or a 12-inch plate and frame filter are typical semi-technical units. Many people are surprised at the first cost of miniature apparatus, one unit often representing an outlay of several thousand dollars, but even so the saving effected on subsequent technical scale work both in first cost of installation and in smooth uniform operation right from the beginning, repays many times over the expenditures necessary in completely equipping a building for semi-technical work. The importance of this stage in developing a process cannot be over emphasized, provided the units are true miniatures of technical apparatus and not a heterogenous collection of pots, crocks and cans. The primary object of work on this scale is obviously to iron out the chemical difficulties in the process incident to changing from laboratory to plant technique at the smallest expense and therefore demands the cooperation of both groups of workers.

The simplest process which we may imagine necessitates as equipment (A) a reactor in whch the reaction may be carried out and in which the variables may be controlled; and (B) a means of separating the desired product. The factors involved in A we will consider first, assuming that the raw materials have been properly prepared to be added to the reaction. In passing, however, it should be noted that a complete installation of type pulverizers should be available, including hammer, ball, disc, ring, cone and combinations. The part played by size of particle especially in heterogenous reactions, is very important.

We have first to consider the "material of construction" of which to make the reactor. The data on corrosion of materials of construction is meager and widely scattered. In regard to the common materials in contact with single common reagents, the result is more or less well known. But seldom, if ever, is the problem as simple as this. Aluminum stands up well against almost any strength of aretic acid, but the presence of an inorganic salt such as sodium chloride, accelerates corrosion greatly. Steel holds up fairly well with as weak sulphuric acid as 60 Baume, provided the temperature is low, but is corroded rapidly at higher temperatures especially if some reduction of the acid to sulphur dioxide takes place. The life of cast iron in contact with sulphuric acid of greater strength than 55° Baume is dependent upon the physical properties of the castings, failures being due to growth of sulphate crystals in the casting. Therefore in securing corrosion data we have not only to deal abstractly with the material of construction and the corrosion agent, but concretely with the impurities and physical condition of the former and the impurities, temperature, pressure and concentration of the latter.

Another important consideration is the effect of the material of construction upon the product being made. Whether the action is catalytic or not, many cases are known in which the main reaction is inhibited, side reactions accelerated, the resulting product being inferior in quality or valueless.

At best any previous information serves merely to limit the possible materials of construction to use. These may then be tried individually in the particular reaction under consideration and the best one chosen.

We have next to consider the design of the reactor. The strength of most of the materials of construction used have been exhaustively studied even at various temperatures so that the proportioning of the various parts,—shell, cover, packet, openings, etc.,—is a simple matter. The shape depends on the surface needed for heat transfer, the type of agitation selected, the pressure obtaining during the reaction, the consistency of the reaction mass, foaming and other minor factors. American practice adheres rather closely to a vertical cylindrical shape with bumped, cone or hemispherical bottom. Some may be found of elliptical cross section. Continental practice seems to have developed toward the horizontal cylinder with bumped ends rather than vertical. The entire reactor is sometimes rotated though usually only the agitator, carried on horizontal shafting through the bumped ends.

The next factor is the control of temperature, or if a closed system, the interdependent control of temperature and pressure.

In cases where the concentration is of minor importance the direct addition of ice or the direct introduction of steam may be used. By the use of ice, the latent heat of fusion is made available just where desired. Obviously this method is the cheapest possible. In cases where control of concentration is important or the nature of the reacting chemicals do not permit of direct addition, heat may be transferred either by means of pipe (coil or straight lengths) or by jacket. Passing from low to high temperatures, the following may be employed: Brine; water; steam, saturated or superheated usually not used over 150 lbs. pressure; circulating oil systems; and direct fire with or without oil or metal bath. Heat should never be applied by direct fire to the reactor shell because of local overheating of both the charge and the shell. If it is impossible to submerge the shell in a bath, then the brick setting should be very carefully designed so that the products of combustion only, impinge on the shell and sweep rapidly around all portions of it, allowing no dead pockets. Direct fired autoclaves carrying relatively high working pressures are liable to failure after months of apparently successful operation, due to continued local overheating. 30-40° C. thermal heat should be allowed for dead jackets and 15-20° C. for pipe coils except on low temperature work, where less may be safely assumed.

Another very important factor lies in the agitation of the reactor. There are almost as many types of agitators as there are designers and hundreds of patented agitating devices may be found in the literature. The commonest are simple paddles inclined at various angles both to the horizontal and vertical, propellors, horseshoes, gates, plows, etc. Recently impellers and cones of relatively high speed are finding application. The factors governing a choice are the phases present and their respective specific gravities, the viscosity of the reaction mass and the desired speed of reaction. Agitation cannot be too thorough and it is unfortunate that no satisfactory units for the expression of agitator performance are available to the chemical engineer. It is usually a case of "cut and dry."

In the following discussion of the apparatus used in isolating a product the classification is made on the basis of the phases present at normal pressure and temperature rather than the mechanical types of equipment available. This is done because, as a rule, the chemical engineer must find or design equipment which will serve under given conditions rather than attempt to adapt the conditions to a given machine. Here again a method of isolation satisfactory in the laboratory may not be adaptable to technical work. Work involving an organic solvent may produce an excellent product but the recovery of solvent from both the product and the impurities involves manipulations which on a large scale become complicated and expensive.

If gases only are present at the end of a reaction a mechanical separation may be used involving either absorption of the desired product in a selective solvent or change of desired product to the liquid phase by cooling or compression or both. Absorption may be carried out by the use of towers filled with packing, spray chambers, horizontal revolving washers, or such relatively new devices as the "Ceco" Spray System or "Feld" Scrubber, these latter requiring expenditure of power. A condition may obtain where the mixture of gases may be collected and used in another process "as is," which is ideal. In the manufacture of dichlor ethyl sulfide, ether and water are removed from ethylene by absorption. In the manufacture of calcium and magnesium bisulfites the crude sulphur dioxide gas is used as produced without separation.

If liquid and gaseous products are both present as such, a simple efficient separator is all that is needed. This may be designed to produce a large temporary decrease in velocity, an abrupt change in the direction of flow, or may utilize centrifugal force or a filter medium.

If liquids only are present conditions may exist varying from complete immiscibility to complete solution. In the case of the former, emulsions present the only difficulty. Various methods of breaking these and thus obtaining a clean face between the phases, are practiced. Application of heat, addition of an electrolyte such as common salt or the addition of more of one or the other of the liquids often promotes breaking of the emulsion layer. Separation of the two phases may then be accomplished by simple decantation or by passing the mixture thru a low speed centrifuge equipped with separator basket. If the emulsion persists, recourse may be had to the high speed super centrifuge such as the "Sharples."

In case a more or less complete solution exists, a number of methods may be used.

The liquid phase of one product may be produced in contact with either that of the other or a solution of both by the addition of a third component such as common salt, an acid or an alkali, solubility changes taking place. Aniline is soluble in water to about 3.5% which solubility is reduced to .5% when the mixture is saturated with sodium chloride.

One component or a mixture of both components in different proportions from that originally obtaining may be secured by passing through the vapor phase. Simple distillation, fractional distillation or steam distillation with or without dephlegmator and with or without application of pressure or vacuum may accomplish the desired result. A mixture of ortho and para nitrochlorbenzols and chlorbenzol may be thus fractionted into chlorbenzol, and a mixture of ortho and para nitrochlorbenzol of varying composition. The construction of vapor pressure curves for each pure material is first necessary. A decision can then often be made on this basis alone as to whether a separation is possible and at what pressure it should be made.

One component or a mixture of both components in different proportions may be obtained by passing through the solid phase. The melting point diagram is constructed, the eutectic point located if one exists and its composition determined. The data are then available upon which the feasibility of this method of separation may usually be decided. A mixture of the nitrochlorbenzols may thus be separated into one pure isomer and a eutectic which may be further fractionated thru the vapor phase.

A differential solvent may be employed as in the extraction of aniline from aniline water solutions after which simple decantation is employed. A means of bringing the solvent and the mixture into intimate contact is essential if this method is to be used. An excellent device consists of a cone bottomed tank connected to a centrifugal pump, suction lines being taken from the bottom of the tank and from the side at such an elevation that both solvent and mixture may be drawn into the pump body where intimate mixing takes place. The mixture is discharged back into the tank. Equilibrium may be established usually in ten to fifteen minutes. Solutions of phenol and water may be exueditiously handled in this manner.

A chemical reaction may be used either to remove the undesirable product or further process the desired body. No special apparatus is necessary. An example is found in the separation of an amine from its solution in an organic solvent such as aniline in naphtha. Addition of hydrocloric acid produces the hydrochloride as a solid or a concentrated water solution if 20° Be acid be used, and the separation is easily made.

Very interesting problems in isolation arise when solids only are present. Separation may be effected again in numerous ways.

Difference in specific gravity together with extent of surface and shape of particle serve as the basis of certain separations utilizing a stream of water or air. A very simple aparatus such as a trough with baffles is often satisfactory. Metallurgical practice has developed a number or more efficient machines the field of which has long since widened beyond ore preparation, such as the "Dorr" classifier and thickener and the "Wilfley" concentrating table. Surprising separations may often be made with the ordinary laboratory elutriator. Air separation when feasible may be combined with pluverizing and transportation, accomplishing a number of operations with one piece of apparatus.

One component or a mixture of both components in different proportions may be obtained by passing through both liquid and vapor phases as discussed in the case of liquids alone. Or the solid may pass directly to the vapor phase which operation is known as sublimation. This may be more successfully carried out on a technical scale by passing air, steam or other gas superheated to the necessary temperature thru the material to be sublimed. Here again accurate data on the vapor pressures of the components at various temperatures are essential, that the proper sublimation temperature may be known. Recourse to this method of isolation is common practice throughout the anthracene series.

A differential solvent may be employed as in the large scale removal of carbazol and phenanthrene from anthracene; or a common solvent may be used followed by the addition of a fourth component such as a salt, acid or alkali to reduce the colubility of the desired product. Careful cooling known in the laboratory as fractional crystallization may be resorted to though seldom feasible in technical work. Simple evaporation is often used generally under reduced pressure. The isolation of practically all the azo dyestuffs is accomplished by employing a solvent for both the dyestuff and the impurities—hot water—followed by the addition of salt with slow cooling.

A mechanical reaction may be employed when a common solvent is used as discussed in the case of liquids alone.

When a solid and a liquid are present as a heterogenous system isolation is purely an engineering problem.

Decantation by means of settling tanks or continuous thickeners may be employed if an incomplete removal of the liquid is permissable. Otherwise recourse is had to a centrifuge or a filter, often erroneously referred to as a press or filter press. Of the former there are slow speed large diameter machines both continuous and intermittent, which operate successfully upon granular or crystalline solids where the ratio of solid to liquid is large. The high speed small diameter super centrifuge is adapted to handling fine almost collodial solids where the ratio of liquid to solid is large. These might be classed as clarifiers.

Of the latter there is a large class of intermittent filters some of which have no shell and movable filter elements as vacuum tank filters; other have movable elements which form the shell when assembled as the ordinary plate and frame and the hydraulic filter and a combination of the two,—the "Carbondale"; others have a movable shell and fixed filter elements as the "Kelly" and "Sweetland"; and yet others which have both fixed shell and filter elements as the old pressure filter and vacuum nutch.

Recently, many continuous filters have been marketed based upon a revolving screw, drum, or disc, the disc revolving either in a vertical or horizontal plane. The selection of the proper filter necessitates the consideration of many factors, the discussion of which is outside the scope of this article.

As filter media, besides cloth woven of cotton, hemp, hair, wool. asbestos and metal, use may be made of sand, charcoal, diatomaceous earth, mattes of various fibers, porous silica brick, etc.

Finally, when a finely divided solid is present in a gas, separation may be made mechanically by using a filter, a washer, or a collector designed to decrease velocity, abruptly change direction of flow, or use centrifugal force. Electrical means may also be employed as carried out by Cottrell.

After the apparatus has been selected, flow sheet and cost estimate prepared, the whole project should again be passed upon by the Director of Research. Then installation is made and semitechnical production carried out. No redetermination of the effect of the variables is necessary unless the laboratory results cannot be duplicated. After at least twenty-five batches have been run and the results are satisfactory, a second report should be submitted in which raw material costs may be accurately calculated, estimates of various fixed charges made ,knowing aproximately the first cost of technical scale equipment necessary, and estimates of cost of labor, maintenance and sundries made. Technical scale apparatus specifications and flow sheet should be included. When this report has been approved technical scale production may proceed.

This stage involves engineering problems primarily. Provided the previous stage has been properly executed no chemical difficulties should arise and no product need be "lost" during this period of experimentation. The field of study involves:

(1) Uniform operation with elimination of hand control of variables, necessitating use of recording instruments, automatic regulators, etc., followed by a redetermination of the effects of the variables on yield and quality of product.

(2) Labor costs.

(3) Repair Costs and life of materials of construction.

(4) Performance tests on apparatus including heat balances and consumption of engineering service (steam, air, water, brine, oil and current).

(5) Modifications necessary to change intermittent operation to continuous operation.

(6) Transportation of materials and preparation of same.

(7) Safety and welfare consideration including control of reaction, fire hazards, ventilation and fume disposal.

With the above points investigated a final report should be submitted, revising all previous ones in detail, with specifications for full scale apparatus and complete cost figures based on at least six months' actual continuous operation.

Upon receipt of this report, the board of directors may intelligently authorize full scale production and appropriate for same, the Engineering Department may prooced with construction and installation without experimentation or fear of failure on performance test, and the Manufacturing Department upon completion of the installation may immediately begin successful operation with workmen already well educated in the process.

ALMOST AS HOT AS THE SUN

The electric furnace in actual use has reached the temperature of 3500 deg. C. Recent experiments have, however, developed a furnace which gives a temperature of 4500 C., enough to volatilize diamonds. A comparison of these temperatures with that of the sun, which is estimated at 5000 C., gives a striking idea of what can be accomplished in handling refractory substances with electric heat.

COMBUSTION OF FUEL OIL.

By Max Sklovsky, '00.

Introduction

Fuel in Industries has become a matter of greater importance in recent years. The low prices in fuel existing until recently have developed wastefulness that has resulted in greater shortages at critical times. It is therefore timely to review and indicate some principles of combustion that a more intelligent use of fuel and particularly fuel oil, may be introduced into practice.

Definition and Object of Combustion

Combustion is generally defined as the chemical union of any material with oxygen, generally the oxygen of the air. By chemaicl union is meant molecular combination. The object of combustion is generally a means of obtaining temperatures for heating or power purposes. The higher the temperature, as a rule, the greater the effectiveness of the heat.

Temperatures

In any combustion process the rise in temperature is affected primarily by,

(a) The heat energy in the material burnt.
(b) The total quantity of the products of combustion.
(c) The dilution of the products of combustion with neutral materials.
(d) The confinement of the space of combustion.

The above items may be amplified and illustrated further in the same order as follows:

(a) A pound of carbon yields 14,500 B.T.Us. A B.T.U. is a quantity of heat necessary to raise 1 lb. of water 1 degree F. A pound of carbon has potentially the power to raise 14,500 pounds of water at 1^0 F., or a smaller quantity of water to a proportionately higher degree. A pound of hydrogen yields about 60,000 B.T.US. and therefore has potentially a higher value as a heat producer.

(b) Considering further the examples under item "a", namely: that of a pound of carbon and a pound of hydrogen and assuming further that the heat generated by combustion is not transferred, that is, the materials of carbon and hydrogen are each respectively burnt in an insulated chamber and the heat resulting goes toward raising the temperature of the products of combustion alone, it would appear at first glance that the temperature of the hydrogen burnt products would be higher than that of the carbon burnt products. That, however, is not the case and in spite of the great difference in the heat energy, the temperature reacher is approximately the same when products of combustion in each case are held under the same pressure. The essential difference lies in that 1 pound of carbon requires 2 2-3 pounds of oxygen whereas 1 pound of hydrogen requires 8 pounds of oxygen, making the products of combustion much greater with hydrogen than with carbon. The heat energy must be distributed, therefore, among the larger quantities of material in the case of hydrogen than in the case of carbon.

(c) The example given in item "a" and "b" indicating a union of carbon and hydrogen with oxygen are ordinarily carried out by supplying air in place of oxygen. Air contains by weight 23% oxygen and the balance or 77% is almost entirely nitrogen, a neutral element. In place, therefore, of supplying 2 2-3 pounds of oxygen, it is necessary to supply to get that amount of oxygen, about 11½ pounds of air and for hydrogen about 34½ pounds of air. The products of combustion including the fuel itself, when accurately combined, is, therefore, in the case of carbon

$$11\frac{1}{2} \text{ plus } 1 = 12\frac{1}{2} \text{ lbs.}$$

and for hydrogen,

$$34\frac{1}{2} \text{ plus } 1 = 35\frac{1}{2} \text{ lbs.}$$

The total heat yielded by a pound of carbon must be divided into the total product of combustion 12½ pounds for each pound of product will contain,

$$\frac{14500}{12\frac{1}{2}} = 1160 \text{ B.T.U.}$$

and for hydrogen,

$$\frac{60000}{35\frac{1}{2}} = 1690 \text{ B.T.U.}$$

(d) Combustion carried on by introducing fuel and air into a chamber of fixed closed space brings about a different result in temperature than combustion taking place either in the open or in a chamber that has free openings in the atmosphere. So that when expansion due to heat takes place, the gases can escape outward. In a confined chamber such as an internal combustion engine where during the period of combustion, the gases are confined, there results an increased pressure and with it an increased temperature.

Air Proportions in Practice

The proportion of air required for complete and exact combustion of any fuel is as indicated above fixed. Ordinarily, however, in the majority of methods of combustion, it is not possible in a practical way to obtain this exact ratio. Generally the quantity of air introduced is much in excess of that required for exact combustion and on this account the temperature is further affected by the dilution of the products of combustion with the excess air. For example, it is well known that in the burning of coal under a boiler, there is air used in excess from 50 to 100%. This excess of air is due to the atttempt of burning solid fuel with air which is a gas. Likewise in the burning of other fuels such as fuel oil which is a liquid even when sprayed in the form of a mist by the ordinary method, excess air is required because of the inability to mix readily liquids and gases.

Mixing

The mixing of gases with gases is readily and almost automatically accomplished and the burning of gaseous fuel with air can therefore be controlled in a very exact manner as to proportion. On the other hand, the burning of fuel in the forms of liquids or solids is not as controllable because of the difficulty of mixing properly solids and gases in any intimate manner. Any method, therefore, by which the fuel is converted into the finest state which is gaseous can be burnt with the greatest control and best proportion and eventually with the best advantageous results from an economic standpoint. Mixing is therefore a basis of proper combustion and the gasification of the fuel permits the best possible mixing.

Conversion of Fuel Into Gaseous Form

(a) Coal, (b) Petroleum and its products.

The conversion of coal into gaseous form prior to combustion has been developed in several ways, the best known being the "Producer" method which is used largely in connection with open hearth furnaces. The open hearth furnace is in itself an extensive piece of apparatus and the gas making apparatus forms a considerable portion of the complete installation. In such furnaces, the gases are conducted directly from the producers into the furnaces in the hot form. For other industrial purposes where small furnaces are used, it has not been found practical to utilize hot producer gas nor frequently the regenerative principle for heating the air supply. The principle employed in the producer is that of forcing the blast of air and with it some steam through a deep bed of coal in a container, producing partial combustion within the bed of coal and distilling off through the heat generated, the volatile fuel of the fresh coal above. This gas usually leaves the producers at temperatures ranging from 1200 to 1500 degrees F.

The conversion of petroleum products into a gaseous form exterior to the combustion chamber, has been accomplished very readily by means of an air blast for the lighter liquids such as naphtha as in the application of gasoline engines. Petroleum fuel products of the heavier kind have been utilized in the gaseous form by a distillation process or by what may be called the boiling process. Where the heavier oils are used, the disutilized directly. Where the rate of consumption of the gas is not utilized directly. Where the rat of consumption of the gas is not concomitant with the rate of production or distillation, a container must be furnished to take care of the difference.

It is apparent therefore, that the conversion of coal or heavy petroleum products into gaseous form involves extensive apparatus beyond the equipment required to consume the gases. Any method by which the conversion may take place immediately or within the furnace in some simple way, has a superior advantage. Preferably a method of conversion that is automatic, requiring no removal of residue, and a method with which no hazard is connected, is obviously most desirable. Incidenally any method of utilizing this gaseous fuel must also be free from such detriment as excessive oxidization. And in addition to the above, economy must be an important factor of such method.

Fuel Oil

This discussion deals primarily with the combustion of fuel oil. Fuel oil is a residue of petroleum oil after the lighter produts or naphthas have been removed. Ordinarily fuel oil contains by weight about 86 per cent carbon, 12 per cent hydrogen and the balance, or 2 per cent, other materials such as sulphur and ash. The above proportions vary only slightly with the different grades and sources of the fuel oil. The percentages of carbon and hydrogen being approximately uniform, it is to be expected that the heat value per pound of fuel oil would not vary a great deal. This has been found to be the case and this heat value ranges between 18500 to 19000 B.T.Us.

Crude oil or petroleum oil being the source of fuel oil, gives to the latter charactertistics, depending upon the source and treatment of the crude oil. For example the crude oils of the Eastern States are lighter in specific gravity and are more fluid than the crude oils of the Southwestern States and particularly the Mexican oils. The fuel oils are likewise affected, ranging from about 6½ pounds per gallon for the Eastern oils to about 7½ pounds for the Southwestern fuel oils. Also the Eastern fuel oil, like the crude, is fluid at ordinary temperatures but slightly less viscous and in winter temperatures the viscousity increases so that it does not flow readily through piping unless under considerable pressure.

The Eastern crude oils are known as the paraffine base and when successively distilled off shows a range of product designated by the formula,

$C_n H_{2n+2}$ and contains compounds beginning with,

CH_4, $C_2 H_6$, etc., $C_4 H_{10}$, etc., to $C_{19} H_{40}$

The above is the simple paraffine series. The Eastern oils are designated as the paraffine base oils while the Western are designated as the Asphaltum base oils. The composition of crude oil is very complex and it is not here the intention to go into that except to mention that the asphalt base oils contain more of the heavier compounds and less of the simpler compounds. It will be noted that the simpler compounds containing somewhat larger proportions of hydrogen than the heavier compounds and hence the greater fluidity. This is reflected in the fuel oils as indicated above.

The treatment of the crude oil as indicated affects the fuel oil residue, the more the lighter compounds are removed, the less fluid becomes the residue of fuel oil. What is known as the cracking process wherein a greater proportion of gasoline is removed from the crude oil which means that the hydrogen is removed in a greater ratio, the less fluid the residue of fuel oil becomes.

Experiments carried out with some fuel oils indicate that below 300 degrees F., the quantity that is vaporized is negligible. That between 300 degrees to 500 degrees F., only a small portion of the fuel oil can be vaporized. When raised to a temperature of over 500 degrees, the fuel oil commences to vaporize more extensively and when 700 degrees is rached, the fuel oil is substantially vaporized. At 800 degrees, it has been found that it is completely vaporized except for a minute quantity of solids, this quantity being under 1%.

Burning Fuel Oil by Spray Method

Fuel oil when poured into an open vessel and lighted, will burn with difficulty and such burning will go on sluggishly forming a heavy dense smoke with a slight dull red flame of moderate temperature. In that condition, the air is not sufficiently mixed with the oil and the combustion is very slow.. As indicated before, to burn fuel it must be mixed intimately with air. The earlier methods of burning fuel oil utilized the oil in the form of spray. A fine spray surrounds itself with considerable more air and is mixed more intimately than when the oil is in bulk. Several methods have been utilized of spraying the oil all involving practically the same principle, namely, that of putting the oil under pressure, ejecting through a fine orifice and supplying at the same time a current of air generally crosswise of the stream and thereby breaking the oil up into a spray. Pressure is required both on the oil and on the air to accomplish the spraying and mixing and in order to carry this mixture into the combustion zone of a furnace, the mixture must be given velocity sufficiently high to carry it over the distance without permitting the oil to drop down and separate itself out from the mixure with the air. For this purpose velocity becomes an element in maintaining the mixture for combustioon. This method of spraying has wrongly been called atomizing. While the particles of oil thus sprayed in, may be very fine and float readily for a while in the air current, they are, however, billions of times as large and as heavy as the individual molicule of oil and such particles of oil are comparatively very dense masses as compared with the air molicules.

It is evident that no matter how fine a mechanical oil spray may be made, it will not mix as thoroughly and intimately with the air as when such oil is converted into a real gas. Combustion therefore is not as rapid when oil is sprayed in as when it is introduced in a gaseous form. The result is that with a spray method combustion lags, that is, it does not take place immediately at the entrance into a combustion chamber. In very large furnaces the stream of the mixture will travel several feet before ignition takes place, and the part of the furnace next to the entrance of the mixture is inert as far as combustion is concerned. In smaller furnaces, the stream travels until it hits an obstacle such as the wall of the furnace on the opposite side and is therefore checked in velocity. It is mixed due to the impact and the oil is then partly vaporized by coming in contact with a hot wall or brick work, and combustion then starts accordingly. On this account it is frequently seen that combustion takes place against one side of the furnace.

It may be stated in general that in the burning of fuel with a spray, a time element exists though very small by the end of which time the mixing and ignition takes place. As the velocity required to inject the mixture is quite high, that is, usually 200 to 500 ft. per second, it is obvious that in a small furnace of one or two feet or even somewhat greater in length, the mixture will reach the opposite end of the furnace within an excedingly small fraction of a second, generally in not sufficient time to permit complete combustion after ignition has taken place. The common observation is that where an outlet from the furnace is available, the high colored flame emerges from the furnace and the combustion is completed after the mixture has left the furnace. It is obvious that combustion that takes place after the fuel has left the furnace is of no value. The important task, therefore, is to confine within the combustion or heating chamber, the fuel and gases until the combustion is complete and has yielded up part of its energy toward heating the furnace and its contents. Within the exeecdingly short time allowed, it is therefore important that the mixing of the fuel and air be given special attention so that the combustion will take place when and where desired. In the spray type of furnace this combustion is acceleraated by injecting an excessive amount of air with the fuel so that combustion will take place more rapidly or by an elongation of the furnace to allow greater time for combustion. This excess of air supplied for the purpose of rapid combustion and for the elimination of smoke, has its drawbacks which can be gathered from the first paragraph, namely:

(a) Lower temperatures are obtained with excess air.

(b) Slower heating results on account of lower temperatures.

(c) It takes more fuel because of the lower temperatures.

(d) The excess aid furnishes an oxidizing agent which in metallurgical furnaces is objectionable.

The prime reasons for introducing excess air is, as noted, to obtain more rapid combustion and avoid smoking. It would appear, however, at first glance that an exact amount of air would be sufficient for operation. Several actions occur in a spray method that prevent this, namely:

When air and oil are simultaneously injected into a furnace at a velocity, resistance against this flow is met with by the gases within the furnace. The air being light loses in velocity very rapidly. Oil, on the other hand, being dense even though in small particles being approximately 1,000 times as dense as the air particles, has greater momentum and loses less in velocity than the air. In other words, is the mixture has traveled a distance into the furnace, the oil due to the greater velocity separates itself out in part from the air medium surrounding it and travels on. In order that the oil may have a sufficient quantity of air to burn in, after it has traveled some distance, an excess of air must be supplied so that the farthermost part of the furnace away from the inlet of the mixure will have a sufficient quantity of air to burn the oil. The near part of the furnace, that is, adjacent to the inlet, has therefore the largest supply of excess air. This excess air being present in the furnace absorbs from the furnace radiation heat reflected in the furnace and lowers the average temperature of the furnace thereby. In contrast with liquid fuel, when gaseous fuel is injected with a mixture of air into a furnace, the mixture is not only thorough but insures a homogeneous maintainance of both the fuel and the air and thereby avoids separation due to any resistance against the current.

Velocity

It will be seen from the foregoing that velocity is an important agency required in the combustion of fuel oil and similar fuels. Specifically velocity is given to the injected air so that,

(a) It will break up the stream of fuel that is introduced in its path in a fine spray.

(b) The velocity is necessary so as to permit the flotation of the small liquid particles of oil in the spray without permitting this oil to drop downward. The carrying capacity, is in proportion to a high exponent of the velocity.

(c) The velocity in some applications induces an auxiliary air curren to float in along with the stream under pressure. This latter is utilized in what is known as the high pressure burners wherein a small part of the air is under pressure and the balance is induced from the atmosphere through an opening immediately surrounding the burner.

While velocity is created for the purpose of assisting in the combustion of oil, it has also its disadvantages, which may be pointed out as follows:

(d) It tends to carry the fuel mixture toward one end of the furnace.

(e) It takes part of the fuel out of the furnace before combustion takes place.

(f) It causes strong impingement of the liquid particles against the wall of the furnace resulting in a washing action and the rapid deterioration of the brick work.

(g) Unequal heating in the furnace results in consequence of the unequaling distributed combustion occurring.

Combustion Chamber.

As a remedy for some of the foregoing difficulties met in connection with the spray method of burning oil, the most common method that had been adopted is the addition of a combustion chamber to the furnace, separate and more or less distinct from the heating chamber. The effect is mainly to divide the furnace into two sections, one in which the combustion is started and the other in which the combustion is finished and also in which the heatig effect obtained is more uniform. To get the proper results such a combustion chamber must be of appreciable proportion of the heating chamber and for the best results, this should be about one-third of the size of the heating chamber. The advantage of a combustion chamber is mainly for a better distribution of heat and for a somewhat reduced oxidization effect. The disadvantages of a combustion chamber, separate from the heating chamber, are:

(a) The heating is accomplished not at the highest temperature of the combustion chamber, but at a secondary temperature lower than in the combustion chamber which is maintained in the heating chamber.

(b) The furnace is increased in size by about one-third and with it the stand-by losses are clearly increased.

(c) The insulation of the combination chamber maintaining thereby a localizing high temperature that is not subject to cooling, results in rapid deterioration of the brick work. This result is commonly known as "Hot Spots."

Vaporizer Method.

To eliminate the excess air in burning oil and at the same time obtain perfect combustion within the furnace proper without increasing the size of the furnace or adding to it in the way of combustion chambers, the vaporization and mixing of the oil and air prior to the entrance into the furnace has been accomplished. In this case, the air is supplied under pressure, is forced through heating chambers which utilize the heat of the escaping gases and the air is further forced from the heating chambers through a vaporizing chamber into which near the inlet, there is supplied the necessary fuel oil, the oil being introduced into a stream of heated air and passing through the vaporizer, together with the air, absorbing the heat from the air and by the time the exit of the vaporizer is reached, the oil is completely vaporized and intimately mixed with the air from which point it is conducted through a tube directly into the combustion chamber of the furnace. In his method the air is maintained not less than 500 degrees and not over 800 degrees. Preferably the air should be 650 to 700 degrees. The tube connecting the vaporizer to the combustion chamber is so proportioned that the velocity of the mixture through it will be sufficient to prevent a recession of the flame from the combustion chamber back into the tube and into the vaporizer. The result is that combustion takes place immediately upon entrance into the combustion chamber, maintaining therefore, a uniform temperature in the combustion or heating chamber. The oil burns wth the exact amount of air chemically required, which results in giving higher temperatures within the furnace, and consequently more rapid heating and therefore economy in the use of fuel. Incidentally, the combustion chamber being uniformly of high temperature, is smaller in size and on this account offers low radiation surface to the exterior. The absence of excess air diminishes the oxidization effect on the material.

This method has proven very successful in obtaining higher efficiency in metallurgical furnaces due to exact combustion. Net savings in fuel oil have been shown by numerous tests varying from 20 to 70 per cent of the fuel previously used for exactly similar heating operations. M. S.

(To be continued

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According to the scientists the ordinary flow of the river at Horse Shoe Falls, Niagara, is 275,000 cubic feet per second, developing an unharnessed horsepower of approximately 5,000,000 or the power of 15,000,000 strong draft horses, each horse being confined to an eight hour day.

THE DIESEL ENGINE IN PRACTICE.

By C. E. Beck, '11.

What is the Diesel Engine doing in practice? This question is often asked the writer because little is published on the subject since most books and papers written under the title of the Diesel Engine deal with the thermodynamical phase of the subject, laying particular stress upon the wonderful fuel economy of this type of prime mover, but showing few actual records of its performance in the field.

It is not the purpose of this paper to outline the sequence of historical events indigenuous to the internal combustion engine, other than to briefly outline the outstanding events which characterize the Diesel engine. The first patent rights were secured in 1892 by Dr. Rudolph Diesel, a German engineer, the inventor. In this he outlined an engine, designed to use powdered coal for fuel, the idea being to compress air adiabatically in a cylinder and at the end of the compression stroke, introduce a charge of fuel through a properly timed rotary valve or hopper. The fuel charge was varied to suit the load, by a suitable governing device actuating the rotary valve.

A second claim in the patent of 1892 was the introduction of liquid fuel, instead of coal and spraying the liquid into the cylinder, but not employing the high pressure injection air feature. The engine was to be started by some explosive agent and the expansion carried to so low a point as to serve as a cooling medium in the cylinder jacket. An engine embodying these features was built, but exploded upon making the first revolution. The builders became discouraged at Dr. Diesel's persistent efforts to accomplish results without water cooling the cylinder and so deviating from his ideas they actually employed the water cooling feature and produced an engine that ran. This engine, however, would not carry a load. It also differed from the original idea in that the fuel was admitted under constant pressure, while Dr. Diesel contemplated the introduction of the fuel at constant temperature. Progress was slow until 1897, when a 25 H.P. single cylinder engine was claimed to be the first commercial success.

Between 1896 and 1898 Mr. Adolphus Busch of St. Louis, Mo., secured the exclusive American shop rights on the Diesel engine and as early as 1898 had constructed a two cylinder 60 H.P. vertical engine which was operated in the Anheuser-Busch Brewery in St. Lewis. Actual records now divulge the fact that this engine was really the first successful commercial machine.

Development of the engine in the United States was greatly retarded because of its newness and because the exclusive shop rights were held by one man. In Europe more rapid strides were made as licenses were granted to several manufacturers and because of their large facilities for experimenting, Diesel engines were soon in operation in various industrial plants. Sulzer Bros., of Winterthur, Switzerland, were the first to get well started and up to the present have built over three million horse power, both stationary and marine types, and in sizes ranging from 25 to 4000 H.P.

In this country, the Diesel Motors Company of America first undertook the manufacture of the engine, then later it became the American Diesel Engine Co. Neither of these firms was a financial success and finally, about 1910, Mr. Adolphus Busch made arrangements to associate the American interests with Sulzer Bros., of Winterthur, Switzerland, and completely reorganized the company under the name of Busch Sulzer Bros., Diesel Engine Co., of St. Louis, Mo. A complete new factory was built for the exclusive manufacture of the Diesel engine, and up to the present about 500 engines have been built in sizes ranging from 75 to 900 H.P. Units as large as 3300 H.P. are under contemplation, the use of which will be principally in the marine field for propelling cargo ships.

Since the expiration of the Diesel patents, about fifteen other American manufacturers have taken up the building of the Diesel motor, about twelve of them adhering to the vertical multi-cylinder design and the others preferring to carry out the old American trait of developing reciprocating machines along horizontal lines and in units of one to four cylinders.

Figure 1 is a sectional side elevation of the injection air compressor and one cylinder of a four cylinder vertical Busch Sulzer Diesel engine, and Figure 2 is a sectional end elevation. It will be observed that essentially, the engine consists of a sub-

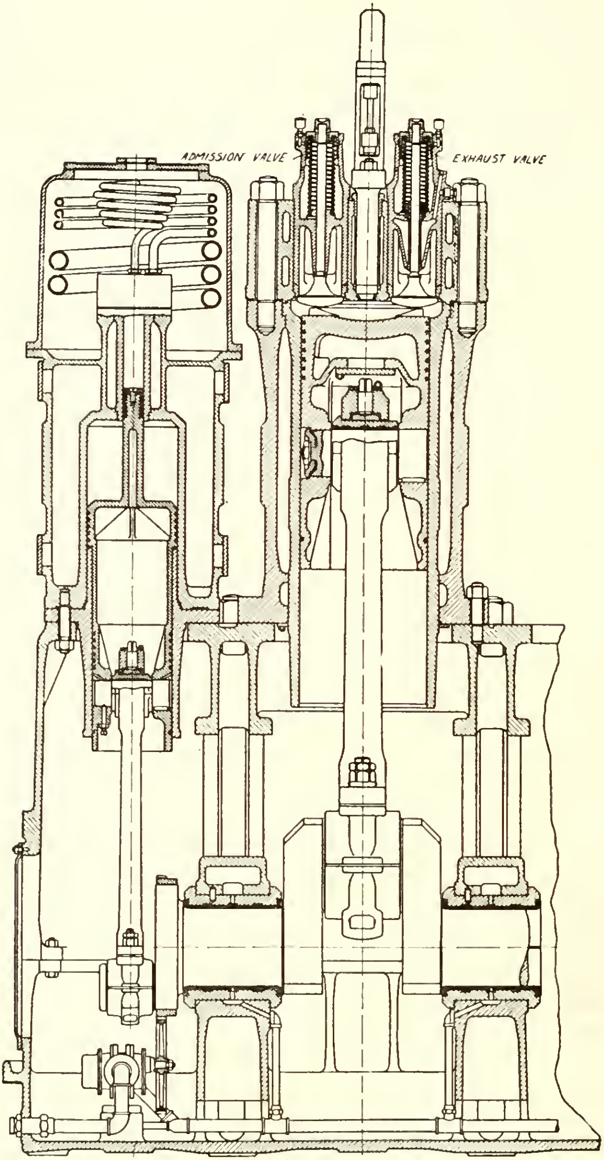

Fig. 1.

base, crank shaft, crank case, cylinder with removable liner, connecting rod with trunk piston and gudgeon pin and cylinder head which contains intake, exhaust and fuel valves shown in

Figure 1, and starting valve shown adjacent to the fuel valve in Figure 2. These engines are all built in the four cylinder vertical type and what appears to be the fifth cylinder shown in Figure 3, is a three stage injection air compressor. This compressor operates at engine speed and supplies compressed air at a pressure of 45 to 65 atmospheres to the fuel valves where it serves to spray the fuel oil into the cylinder upon the opening of the fuel valve. Air in the cylinder is compressed adiabatically to 480 pounds pressure and at approximately the end of the compression stroke, the spray or fuel valve opens and the fuel oil in a nebulous form enters the cylinder with ignition taking place at once due to the temperature caused from the high compression. Admission of fuel continues for about 10% of the stroke when operating under full load.

In compressing air in three stages, the compressor is equipped with inter and after coolers shown in the form of coils in Figure 1. These coils are fitted with suitable drain cocks for removing the entrained water which otherwise would be injurious to the fuel valve needle. Small particles of water passing through the fuel valve have the same erosive effect as wet steam has upon steam turbine blading.

Some manufacturers, especially those preferring to build engines of the horizontal type, offer them in one, two, three and four cylinders, reaching three and four cylinders in engines of 450 H.P. and larger. These machines find their field largely where close regulation is not required, such as for driving pumps, industrial plants and the like. It has been found that, because of the high economy of the Diesel engine, it has a wide field, thus requiring an engine so designed as to be practically universal in application. For instance, to drive direct connected 60 cycle, alternating current generators in parallel, requires an engine having an angular velocity variation of not more than 1 to 300 and to accomplish this, four cylinders are quite necessary. Therefore, if an engine meets the requirements of parallel operation on 60 cycle current, it will meet any other specification. Successful parallel operation is now being attained in numerous central stations and municipal electric light plants.

To attain a thorough working knowedge of the Diesel engine is the ambition of many now following the engineering profession, but in a sense, the engine is still in its infancy. Not enough engines have been built, nor have they been in operation sufficiently long to acquire the knowledge of them that we have of the automobile engine for instance. The most complicated problems have been confronted in Diesel engine design and operation, and while there are hundreds now installed, there is still plenty of room for development.

The present cost of the Diesel is about $115.00 per horse power and while this seems high, there is little chance of their becoming cheaper until the engine is much more simplified and more of them built. Diesel engines require the highest grade of materials and workmanship known to the art, and the task of selecting proper materials together with their proper treatment and machining is one that requires years of experience.

The breaking of crank shafts characterized the Diesel and so-called semi-Diesel engines for years and became a most serious barrier in the way of their success. The Busch Sulzer Diesel Engine Company secured a great many shafts from the Krupp Works in Germany, believing that we could not duplicate the material in this country. The Krupp steel ran upwards of 80,000 pounds in tensile strength, 48,000 pounds elastic limit, with elongation 25 per cent, and reduction in area 45 per cent. In carbon this steel ran .45 to .53 per cent, manganese .55 to .70 per cent, silicon .12 to .15 per cent, and .03 per cent, in both sulphur and phosphorous. Our American shafts would scarcely exceed 60,000 pounds tensile strength, and 35,000 pounds elastic limit. Later, however, it was learned that American steel could be made to conform with the most rigid physical and chemical analyses, but in spite of all this care in securing the highest grade of material, shafts would break. It has always been known that a shaft subject to continued shocks would break if it happened to get out of line, but it was not thought that a shaft .010 in. out of alignment was subject to crystallization and ultimate failure.

Manufacturers applied various ideas in the manner of taking up wear of the main bearings and because it had worked so well in steam engine practice, the usual wedge adjustment was employed. This later proved to be a total failure since it was impossible for the most skilled mechanic to take up a set of bearings and keep the shaft within .010 in. of true alignment. Older builders were not slow to realize the fallacy of the wedge idea and straightway introduced the non-adjustable bearing so as to maintain rigidity throughout the entire set of main bearings. In the vertical engine, babbitted cast iron shells were schaped to a fit in the bed plate and the shaft later spotted in on the babbitt. A top shell was held down by a cup, there being a set of shims between the upper and lower shells. As the lower shells wore, shims could be removed and the top cap brought down, but all bearings will not wear aike. To overcome this, leading builders now provide a gauge for checking the alignment as often as desired and there really should be no further excuse for shaft failure in an approved make of engine.

Before leaving the main bearings a word might be said about the babbitt metal used and the method of holding it to the shells. First of all, ordinary steam engine babbitt will not suffice at all, because it is entirely too soft. The usual method of pouring babbitt into a rough rusty shell and peening it after it has cooled, will not give service in Diesel engine practice. For the oil engine in general a babbitt containing as much as 85 per cent tin must be used so as to secure hardness. The boxes are turned out with dovetail grooves and then the whole inside is tinned so that when the babbitt is poured, there will be a firm bond between the cast iron and the bearing metal. Nn peening is resorted to as it checks the babbitt causing it to later work loose.

Because of the heavy duty called upon for the crank pin boxes to perform they are constructed of a high quality cast steel and are babbitted in the same manner as the main bearings. In steam engine practice, cast iron boxes serve this purpose very well.

Crank pin bolts have been as serious a source of trouble with some manufacturers as crank shaft failures. Some did not design their bolts sufficiently large, but that was not a common error. Crank pin bolts failed and many of them causing some very serious accidents. The cause was finally discovered, it being due to the bolts becoming crystallized. They are always set up very tight putting them under heavy tension, and this combined with the severe duty indigenuous to the engine would cause them to fail. Now a Diesel engine operator is forcibly instructed to remove all crank pin bolts about once a year, place them in an air tight furnace to prevent oxidation, and heat them up to at least 1550 deg. F. so as to thoroughly anneal them. Unless this temperature is reached, the molecular structure of the steel is not affected and the heating does no good.

As formerly stated, the cylinder is a removable liner or sleeve, recessed into the water jacket at the top and held down by the cylinder head. A gasket at the lower end of the jacket prevents leakage of water into the crank case and also allows the liner to expand and contract with entire freedom. This liner is made of a special mixture of cast iron which is close grained, tough and particularly adapted to wear. Its being removable permits of its easy removal for any cause whatever and a new one may be replaced at a nominal cost.

Pistons are of the trunk type and are cast of a special mixture of iron that must be free of silica, sulphur and phosphorous, since these elements tend to render the material brittle, causes it to warp and even results in it growing or becoming permanently larger when subjected to heat. Pistons are turned, ground, given special heat treatment and ground again before ready for use.

The bearing in the piston, commonly termed the wrist or gudgeon pin bearing has been a most troublesome affair. In the earlier engines, a sommon mild steel pin was used having a taper fit in the piston. This had to be abandoned and not only a case hardened pin substituted, but the taper fit in the piston had to be ground. The grinding was necessary in order to attain a perfect fit, correct alignment and rigidity. The boxing was originally of the simple split construction, with babbitt lining and a wedge construction to take up the wear. The wedge idea soon failed because it would cause heating of the box if tightened up so as not to pound. On the other hand, if loose enough not to heat, pounding would develop which in turn would crystallize the wedge bolts. The box is now built on the ordinary split method as shown in Fig. 2, with no liners or shins between the halves. A large set screw entering the top end of the connecting rod holds the boxing rigidly in place. When adjustment is required, the entire piston is removed and wear is taken up by scraping off the metal to metal joint between the two box halves.

Both solid bronze and babbitt lined bearings are employed, the former requiring the better lubrication but necessitating less frequent attention.

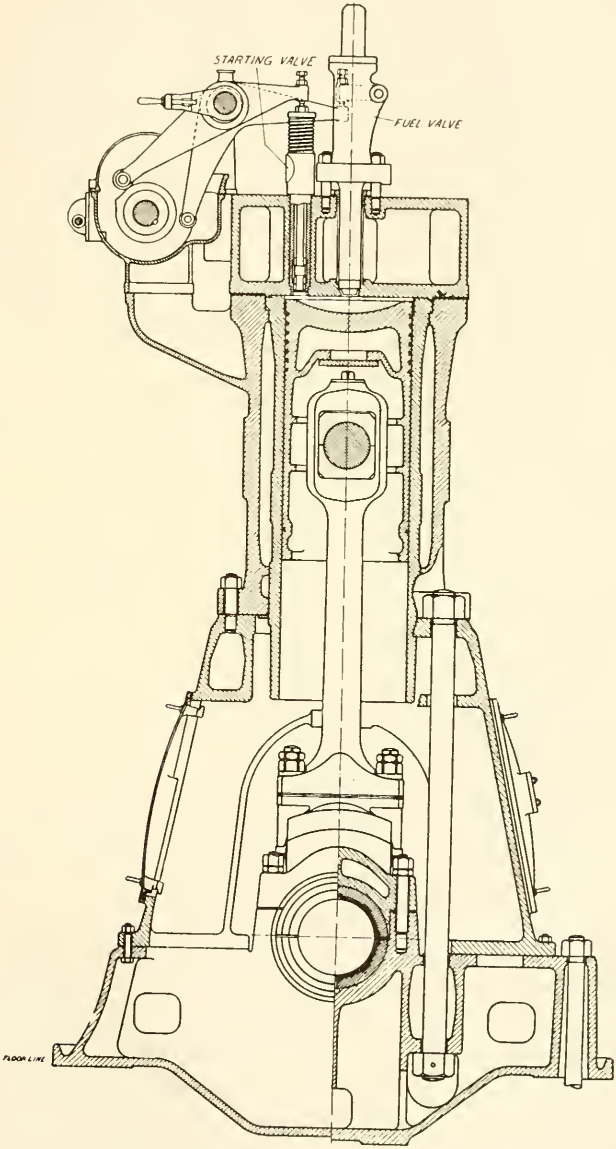

Fig. 2.

The usual Diesel piston carries seven rings at the top end and one, a wiper ring to remove excess lubricating oil, at the bottom. The average width of these rings is ¾ in., but some manufacturers now use a ⅜ in. wide ring on all pistons and find them just as effective as the wider one. Piston rings require a very high grade of material and the best workmanship and care attainable are none too good. The Busch Sulzer Company built 60, 900 H.P. submarine Diesel engines for the United States Government during the war and at one time the piston rings rejected by the government inspectors ran as high as 450 out of 500 rings. The metal cylinder from which the rings are turned is cast in a special mold, of a special mixture of iron that will be neither too hard nor too soft, that will not be brittle and that will not lose its resiliency. As the correct size of he ring is approached in turning, finer and finer cuts are taken to prevent throwing the ring out of round. It is finally slotted and the joint doweled together when it is ground on both sides and then a final cut taken off the outside and inside respectively.

Next to the failure of crank shafts, the most serious difficulty to overcome, has been the breaking or cracking of cylinder heads. The principal causese for this were as follows:

1. Defective material.
2. Unsymmetrical design.
3. Shifting of cores in molding.
4. Improper grade of iron.
5 Overloading of engine.
6. Deposits of scale.
7. Shutting off water too soon after stopping engine.
8. Turning on water after starting engine.
9. Poor circulation of cooling water.

A great many of these causes can be eliminated by care in operation and especially the overloading. The normal rating of a Diesel engine should be determined upon 70 pounds M. E. P. when based on Brake Horse Power, and overloading up to 10 per cent should not be allowed for more than 10 per cent of the running time each day. The load which a Diesel engine will carry is limited only by the amount of oxygen drawn into the cylinders, but this will permit the engine to take on a great deal more load than is safe. Overloading, naturally entails the consumption of more oil and consequently the development of more heat which puts excessive strains on the cylinder head structure and cracking results.

When using hard water ln the circulating system and maintaining an average discharge temperature of between 140 to 160 deg. F., scale will deposit in the head and cause overheating in spots which will result in cracking. This is partially overcome by circulating more water and reducing the discharge temperature of 110 deg. or less. This will also prevent the precipitation of scale to some extent and before it becomes serious, the head must be opened and the deposits eaten out by applying a 50 per cent solution of hydrochloric acid. This process costs about $15.00 on a 350 H.P. engine and often has to be applied every ninety days.

Throughout the Kansas, Oklahoma and Texas territory where water is generally bad, continuous or closed systems of cooling are employed. With this system, rain or distilled water is circulated through a set of coils or a cooler placed in series with the engine. Then the hard water is passed over the coils or cooler and in no way comes in contact with the pure water. In this way no scale trouble is possible and with good care, an engine equipped with this feature should render excellent service.

European practice has demonstrated that above 16 in. diameter, pistons should be water cooled to prevent cracking across the head. A system of sliding tubes carries the cooling water to and from the piston and because the best systems are protected by broad patents, many builders have endeavored to sidestep the idea with the expected inconvenience of having to replace innumerable pistons.

Something of the same idea applies to cylinder diameters in four cycle engines as the limit is reached at about 21 in. diameter. In this case, however, troubles appear to increase as the cube of the diameter if attempts are made to exceed the limit. This naturally means that to manufacture four cycle engines in large powers necessitates going to a large number of cylinders. Six cylinders appear to be about the practical limit and so the only salvation is to adopt the two stroke cycle principle. Sulzer Bros. of Winterthur, Switzerland, have carried the two cycle idea to a high point of development, having built and fully perfected a single cylinder 2000 H.P. engine with patented port scavenging and auxiliary scavenging compressor. This engine had a cylinder diameter of 39.3 in. and a stroke of 54 in. and ran at a speed of 90 turns per minute. They have also built and have in operation six cylinder two cycle engines of 4000 H.P., one of which operated all during the war at Harland and Wolf's shipyard in Belfast, Ireland. During this period the engine was shut down but three times, due to engine trouble.

Referring again to Fig. 1, the intake and exhaust valves are shown in section, the latter being arranged for water cooling. Each valve is placed in a removable cage so as to facilitate inspection and grinding. The seating end of the cages are removable so that new seats may be inserted when necessary. The spray valve is shown between the intake and exhaust valves, it also being of built up construction so as to facilitate inexpensive and prompt renewal of worn parts. Spray or fuel valves require accurate adjustment and regular attention to the packing and lubrication. Earlier designs experienced a great deal of cutting and wear due to grit and acid in the oil. Suitable filters now remove the grit while cast iron, Monel metal and bronze fuel needles, resist corrosion from acid as well as the erosive effect of occasional water particles carried with the injection air.

Acid, grit and asphalt also affected the fuel pump in much the same manner as the fuel valve, but the causes were overcome by the proper selection of non-corrosive metals. The fuel pump is the heart of the Diesel engine and while its construction is of the simplest order, its valves must be kept tight and the packing glands properly adjusted. On small engines, one pump plunger serves two cylinders, while on larger sizes, a plunger for each cylinder is provided.

Next in importance to the fuel pump, is the air compressor as it serves to supply air to break up the oil and blow it into the cylinder. In earlier types of engines this compressor was either motor driven or belt connected with the engine. Compressors had not been perfected that would operate successfully at engine speeds. However, with the introduction of the plate and feather valves, high speeds were attainable and immediately the air compressor became an integral part of the engine.

Many manufacturers used the spring loaded mushroom valve, which while giving fair satisfaction, required entirely too much attention. Some builders tried compressing the air in two stages with the result that it became so heated that in passing over the valve springs their temper was withdrawn and soon a valve would fail to function. Upon the introduction of the three stage compressor with inter and after coolers valve trouble became less acute, although still not satisfactory. The mushroom valve would pound its seat out and become leaky. Later the plate or disc valve was tried, it being a thin circular plate about $\frac{1}{8}$ in. thick by $2\frac{1}{2}$ in. diameter and seated by a light spring. They have a large flat seat, are made of special heat treated, chrome-vanadium steel and give good service with the exception of the springs which were ultimately abandoned entirely as none were required. Air is compressed by a stepped or differential piston in the first two stages while the high stage is a small piston of the regula-

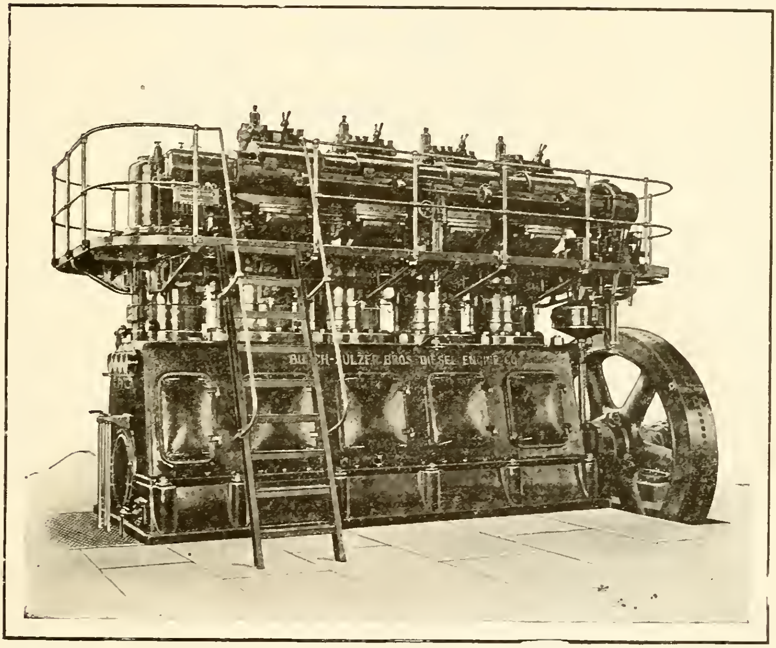

Fig .3. The 4-B-125 Diesel Unit, 500 Brake Horse Power.

tion design. The high stage piston rarely exceeds 4 in. in diameter and is screwed into the second stage piston, thus making it easily renewable. The entire compressor is water cooled and seldom gives trouble from this source. A complete discussion of air compressors for Diesel engines is a topic within itself, and in this paper it is not the writer's intention to do more than cover the subject briefly.

Another subject of wide range and covering years of experimentation is the problem of lubricating Diesel engines. With cylinder temperatures running upwards of 3000 deg. F. and heavy side thrusts of trunk pistons due to connecting rod angularity, very few satisfactory lubricating oils were at first available. And even now, the manufacturer places little stock in the chemical and physical analysis of an oil. There are five or six grades on the approved list and their satisfaction has been demonstrated through actual use. A test will require at least six months operation.

Some engines employ three grades of oil, one for the compressor, one for the cylinders and a third for the bearings. Where a third oil is employed for bearing lubrication, a gravity feed system is generally used with a wall tank to exert pressure on the lines. A settling tank below the engines catches all drains and a suitable pump driven off the engine, takes oil from this settling chamber and delivers it to the wall tank. The air compressor and cylinders are fed by the regular force feed lubricators.

The Busch Sulzer Diesel engine is equipped with the approved European system of lubrication using but one quality of oil on the cylinders and bearings. Fig. 4 shows the system which is force feed throughout, the oil being circulated by a positive pressure pump driven off the end of the crank shaft. The crank shaft and connecting rods are drilled as shown to permit oil to reach main bearings, crank pins and wrist pins. Drippings from all parts fall into the bed plate and flow to a duplex filter and cooler placed beneath the floor. When one filter is in use the other may be removed for cleaning. This system operates at 6 to 15 pounds pressure and insures a thorough flooding of all bearings, resulting in a minimum of attention and wear. The cylinders and compressor are lubricated separately by a force feed cylinder lubricator, the cylinders each receiving oil at four points on the circumference. Large engines receive oil at six points.

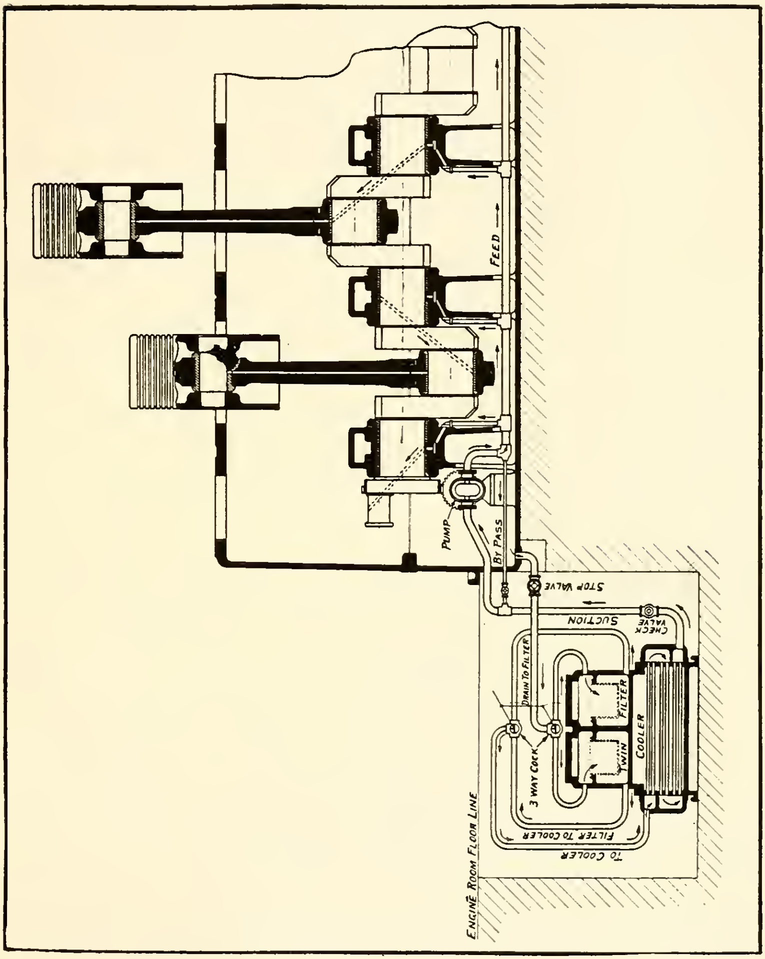

Fig. 4.

The lubriating oil consumption of the average Diesel engine is about one-third gallon per thousand rated horse power hours, and the average price of it is 60c per gallon. The majority of operators use too much lubricating oil, but it is through the fear of not using enough.

The question of the cost of maintenance on Diesel engines has been a much mooted one since it has become quite generally understood, that the engine actually maintains its fuel economy, but some claim that this is entirely offset by the high cost of repairs. In certain instances this is true, but it applies equally to certain steam engine and steam turbine plants as well. To meet these contentions the Busch Sulzer Diesel Engine Company of St. Louis, Mo., compiled a set of figures last October, giving the total cost of repairs on all of their type B engines which they have built since 1914 and which have been in operation at least one year. The results cover engines ranging from 120 to 520 H.P. in size, and run as follows:

Total number of engines shipped prior to Oct. 1, 1918	65
Total number of engines in service Oct. 1, 1919	65
Date of shipment of engine in service shortest period	Sept. 23, 1918
Date of shipment of engine in service longest period	Jan. 15, 1915
Average standard selling price	$22,470.00
Av. cash payments by customers per annum per engine	$618.78
Percentage of cash payments to average standard selling price per engine per annum	2.75%
Average number of years service	3.29

In other words an engine should be kept in good repair at a cost of 2.75% of the selling price per year. Some of these engines actually ran as low as 1% in which case extra good attendants were in charge of the plants. In determining these costs, light on another phase of the subject was sought and that was to ascertain whether the same rate for repairs continued year after year or whether there was a tendency toward its decreasing. On an average it was found that the maximum was reached at two and one-half years with another peak occurring at four and one-half years, but the average reaching only two per cent. This drop in repair cost was attributed to the operators becoming more familiar with their engines and being able to make parts last longer, by careful manipulation of the engines.

Diesel engines installed seventeen years ago are still in successful operation and the present day machine with its more highly developed mechanism and material will have a life of at least twenty years. A modern well designed engine, is arranged so that every wearing part is renawable and should all these parts require replacing at the same time, the total cost would not exceed one-third of the cost of an entirely new engine. This, in fact, renders the life of such a machine almost indefinite.

Few people of today know that the largest user of Diesel engines in this country is the Prairie Pipe Line Company of Independence, Kansas, who are the common carriers for the Standard Oil Company. Over 30,000 H.P. of Diesel engines are in use on their lines as they pump crude oil from Ranger, Texas, to Whiting, Indiana, and Wood River, Illinois. They have engines ranging in size from 100 to 665 H.P. They also have 10,000 H.P. in process of installation and on order. These engines use the raw crude petroleum directly from the lines and because of the high economy of the Diesel motor, they are today making out their triple expansion condensing steam engines and replacing them with Diesels. The steam engine under the most favorable conditions would deliver 1000 barrels of crude oil on a fuel consumption of one barrel. The Diesel performs the same duty on a consumption of one-third of a barrel. Mid-continent crude oil is now worth $3.50 per barrel and with a pipe line system delivering 154,000 barrels every twenty-four hours, one can readily see where the Diesel engine will pay and especially when you consider that this tremendous amount of oil is handled by a pump station every 40 miles.

The Sinclair Cudahy Pipe Line Company of Tulsa, Oklahoma, use something over 80 Diesel engines in pumping oil from Texas to Chicago. Numerous other pipe lines use these engines and it is a fair estimate to state that there are fully 200,000 H.P. in this class of service.

The U. S. Government as well as the leading foreign governments have adopted the Diesel engine in submarines. Our under sea boats use two 900 H.P. units of the two stroke cycle, pump scavenge type, these units being six cylinder machines and operating at 350 turns per minute. During the war some of these engines were installed at the Mare Island Navy Yard in California, and one fleet in particular left there, passed through the Panama Canal, cruised around the war zone for five months and upon returning to Mare Island, had logged 21,000 nautical miles. During this extended voyage no trouble whatever was experienced with the propelling engines.

The Diesel engine has filled a long felt want with the small municipality where they either could not install steam equipment because of the excessive operating costs in many localities or if they already had such an installation, they could not operate on a longer schedule than from dark to midnight each day. In towns of 750 to 12,000 population they have been installed in great numbers and the following pages will reveal the fact that many little hamlets are not only enjoying full twenty-four hour service, but that they pay just as reasonable rates as the larger cities, that they can more easily install electric ranges and that they actually pay oq the entire cost of the plant in five to ten years.

One of the most promising fields for the Diesel engine is in the merchant marine where rapid progress is being made and especially in foreign countries. The East Asiatic Company of Copenhagen will soon have twenty or more Diesel engined cargo ships in service. Innumerable other shipping concerns have ships on order that will be propelled by Diesel engines. Most of these, however, are foreign companies, as our shipping interests either do not care to see us acquire a powerful merchant marine or they are oblivious of the merits of the Diesel engine. Some 1200 ships are now equipped with oil engines. As an example of what may be accomplished with Diesel motored ships in competition with steam driven ones is indicated by the freight rates quoted some months ago on cargo destined to Honolulu from both New York and Liverpool. A Diesel motored ship quoted $27.50 per ton from Liverpool to Honolulu and a steam propelled ship quoted $33.00 per ton from the port of New York. In other words, the Diesel ship, because of its superior economy, its increased cargo capacity and its lower labor cast, could carry freight three thousand miles farther at a much lower rate.

The first set of operating records are shown in Table 1, they being that of the central station located at Hiawatha, Kansas. The plant consists of one 250 H.P. and one 365 H.P. Busch Sulzer Diesel engine, and it will be observed that the gross cost of manufacturing electrical current over a period of five

TABLE 1

OPERATING RECORD

HIAWATHA LIGHT, POWER & ICE CO., HIAWATHA, KANS.

May to September, 1919.

Month	May	June	July	Aug.	Sept.
Interest	$ 218.70	$ 218.70	$ 218.70	$ 218.70	$ 218.70
Depreciation	245.53	245.53	245.53	245.53	245.53
Insurance	91.20	91.20	91.20	91.20	91.20
Taxes	38.00	38.00	38.00	38.00	38.00
Engineers	243.75	243.75	243.75	243.75	263.75
Lubrication	1.8.79	128.19	128.19	128.19	128.19
Water	7.00	7.00	7.00	7.00	7.00
Manager (Pro Rata)	45.00	45.00	45.00	45.00	50.00
Fuel Oil	433.85	315.98	365.63	383.79	350.43
Repairs and Supplies	24.81	463.00	23.98	36.70	96.11
Extra Labor	100.00				
Current for Water Pump	60.00	60.00	60.00	60.00	60.00
Current for Station Light	12.00	14.00	14.76	15.32	15.20
TOTAL	1648.03	1870.35	1481.74	1513.18	1564.11
K. W. Generated	80100	97878	102205	124026	108405
Cost per K. W.	.0205	.0191	.0145	.0122	.0144
INCOME	2867.82	3036.20	3175.90	3290.60	3639.47

Average gross cost per K.W. .... $.0161
Load Factor .... 37 per cent
Plant Profit (Distribution charges not deducted) $7932.58
Average return per K. W. .... $.0312

1 250 H.P. Busch-Sulzer-Diesel Engine
1 365 H.P. Busch-Sulzer-Diesel Engine

TABLE 2

OPERATING TABLE OF 365 B. H. P. BUSCH-SULZER-DIESEL ENGINE DRIVING 250-K.W. GENERATOR AT ALGIERS SHOPS OF M. L. & T. R. R., ALGIERS, LA.

Month	Fuel Oil Gallons	Fuel Oil Cost	Water Gallons	Water Cost	Attendance Cost	Lubricants and Supplies	Repairs, Material & Labor	Total Cost	Hours Operated	K.W.H. Generated	Cost per K.W.H.
1918											
April	2,304	$115.20	721,250	$55.00	$ 87.50	$ 5.55	$38.00	$301.25	245	26,910	1.12 c
May	2,435½	121.77	778,750	58.76	87.50	6.19	43.00	317.22	267½	30,055	1.06
June	2,041½	102.75	603,700	45.28	87.50	5.78	37.00	278.31	226½	28,535	.975
July	2,533½	126.67	977,500	58.31	87.50	6.85	28.00	307.33	282	35,400	.868
August	2,289	114,45	697,500	52.31	87.50	8.05	31.00	293.31	249	32,270	.908
September ..	2,356	117.80	667,500	49.73	90.00	9.31	33.00	299.84	243	32,120	.934
October	2,541	127.05	787,500	57.13	105.00	12.93	41.00	343.11	282½	38,425	.823
November ...	1,968	98.40	657,500	49.03	176.00	15.00	60.25	398.68	234½	35,760	1.115
December ...	2,830	141.50	743,750	52.06	179.39	16.00	38.00	426.95	267½	41,690	1.01
1919											
January	3,524	176.20	902,500	66.17	259.00	14.60	21.00	536.97	327½	50,830	1.56
February	3,744	187.20	1,002,500	71.57	240.00	1126	24.48	534.51	408	55,150	.969
March	3.905	195.25	1,160,000	81.20	264.00	25.20	63.30	628.95	456½	59,230	1.62
April	4,327	216.35	1,205,000	84.35	256.00	14.00	41.64	612.34	461½	60,965	1.004
May	4,672	233.60	1,220,000	85.40	264.00	12.33	16.32	611.65	474½	62,585	.977
June	2,978	148.90	637,500	44.62	133.20	11.81	16.32	354.85	252	46,400	.765
July	2,889	115.56	587,500	41.12	189.96	10.75	27.20	384.59	207	48,200	.777
August	2,800½	112.02	585,000	40.95	185.72	12.04	.....	350.73	205½	50,110	.70
September ...	2,681	107.24	562,500	39.37	179.20	11.04	.....	336.85	198	44,640	.754
October	3,173	126.92	697,500	48.82	183.96	11.18	38.01	408.89	235½	49,920	.819
November ...	2,981	119.24	600,000	42.00	182.52	19.29	69.00	423.05	216	44,360	.953
December ...	3,650	146.00	730,000	51.10	193.80	30.59	11.92	433.41	265	51,790	.837
1920											
January	4,089½	163.58	745,000	52.15	196.20	11.09	32.68	455.70	273	52,350	.87

Average net cost per K.W.H.	.9375c	Cost of Plant	$33825.00
K. W. hours per gallon fuel oil......	14.6	Fixed Charge per K. W.	.73
Average load K. W..................	154.3	Gross cost per K. W.	1.5675c
Load factor	22 per cent		

months was 1.6c per kilowatt. This plant is now installing another 356 H.P. outfit which will be ready for the heavy summer load. Nine other surrounding towns receive power from Hiawatha over high tension transmission lines.

In Table 2 is shown a twenty-five months record of a 365 H.P. Busch Sulzer Diesel engine in Morgan's Louisiana and Texas Railway Shops, located in Algiers, a suburb of New Orleans. This is a phenomenal installation in that with only a 22 per cent load factor, the total gross cost per kilowatt is only 1.57c. The repair cost, including labor, is very nominal and is scarcely 2% of the selling price of the engine. This conforms closely with figures given earlier in this article. On the whole, the record shows the possibilities of the Diesel engine in an industrial plant.

The next record is that of the city of Baldwin, Kansas, shown in Table 3, a town having a population of 1400 people, and enjoying full twenty-four hour electrical service with but one unit. The gross cost per K.W. is 2 1-3c and since the lowest rate is 3c there is a profit on every unite of electricity manufactured at the power plant. The engine receives average attention, maintains a high load factor and has an unusually low rpair cost. Another noticeable feature of the record is the fine profit earned over and above the gross operating expense. This plant will not only pay for the oil engine in five years, but in addition, wipe out the bonded indebtedness caused by the installation of two gas engines that were abandoned because of the gas supply running out.

Another excellent example of what the Diesel engine will do for the small town is shown in Table 4. This is a three year record of the city of Marion, Kansas, and in spite of the fact that the plant consists of only one 120 H.P. and one 165 H.P. unit, the combined net profits for the three years is $21146.96. This is a town of about 2500 population, located in central Kansas, and its citizens enjoy just as reliable and cheap electric power as is obtained in any of the larger cities.

TABLE 3

CITY OF BALDWIN, KANSAS

Operating Record April 1st, 1918, to April 1st, 1919

	Gals. of Fuel Oil	Fuel Oil 5c per Gal.	Gals. of Lubr. Oil	Cost of Lubricat'n	K. W. Hrs. Generated	Labor Cost	Repairs, Supplies	Water & Light Gross Revenue
April	3,861	$ 184.05	89.75	$ 52.22	29.065	$ 310	$ 1.90	$ 1,286.70
May	3,527	176.35	86.75	50.84	31,775	310	2.20	951.37
June	3,716	185.80	96.75	56.80	32,885	310	3.00	992.96
July	3,841	191.05	124.00	72.25	34,185	310	35.00	1,112.50
August	4,344	217.20	96.75	56.80	42,057	310	6.60	981.85
September	3,620	181.00	93.75	54.84	33,667	310	1.60	1,187.92
October	3,686	184.30	96.00	56.22	32,230	310	1.60	1,647.37
November	3,712	185.60	89.25	52.26	35,768	310	2.40	1,382.25
December	3,657	182.85	91.75	53.64	35,684	310	1.40	1,416.09
January	3,899	194.95	89.75	52.22	39,673	310	1.60	1,239.40
February	3,365	168.25	78.75	45.86	31,295	310	1.90	1,380.03
March	3,505	175.25	124.00	72.10	31,240	310	2.10	1,345.17
Total	44,733	$2,236.65	1,157.25	$676.05*	409,524	$3,720	$61.30	$14,923.61

YEARLY SUMMARY

Fixed Charges—

Interest .... 6% Depreciation ... 5% Insurance ..... ½%	11½% on investment of $25,000.00	$2,875.00

Operating Charges—

Fuel oil, 44,733 gal. at 5c per gal.	$2,236.65
Lubricating oil, 1,157.25 gal.	*676.05
Maintenance, waste, supplies, repairs	61.30
Attendance: 1 chief engineer at $120.00 per month, per year	1,440.00
2 assistant engineers, at $95.00 per month, per year	2,280.00
Gross operating cost	$14,923.61

Gross revenue	$14,923.61
Gross cost per K. W. hour	2.33c
Net revenut	$5,354.61
Net financial return on Diesel Engine investment	31.5%
Net financial return on entire plant investment	21.4%
Average weekly shut-down	3 hours
Per cent of total possible time engine operates	96.3%
Yearly load factor	41%

---

*No effort made to economize on lubrication.

Table 4.

FINANCIAL REPORT OF THE CITY OF MARION, KANSAS, WATER AND LIGHT PLANT — SHOWING RECEIPTS AND EXPENDITURES

WATER DEPARTMENT	1917	1918	1919
Income—			
Water Sales	$3532.62	$3998.19	$3874.66
Meter Rentals	225.15	22.90	238.81
Fire Protection, Sewer Flushing, etc., (by taxes)	2150.00	2455.64	2653.01
Miscellaneous	38.55	39.55	45.42
TOTAL	$5956.32	$6717.28	$6811.90
Operating Expenses—			
Electric power for pumping	$2364.00	$2128.01	$1664.74
Pump Station expense	335.72	390.41	73.83
Upkeep of Mains, Fire Hydrants, etc	433.36	111.43	271.28
Meter repairs	37.85	45.42	73.49
Superintendence and undistributed	502.54	825.75	920.64
Interest on water bonds	2160.00	2160.00	2160.00
TOTAL	$5828.47	$5661.02	$5163.98
Net gain from Water Department	$127.85	$1056.26	$1647.92
LIGHT DEPARTMENT			
Income—			
Commercial and Residence	$7089.56	$7687.39	$11112.61
Cooking and heating	617.69	960.35	1371.74
Current for Pumping Power	2364.00	3472.30	1664.74
Other Power	1092.90	2128.01	2373.96
Street Lighting and upkeep (by taxes)	2540.00	2455.64	2653.01
Miscellaneous	182.82	129.86	102.29
TOTAL	$13921.27	$16878.77	$19330.17

Operating Expenses—			
Engineers' Salaries	$1954.00	$2491.23	$3059.42
Fuel Oil	1746.10	3523.36	2599.95
Lubricating Oil	297.96	386.55	351.46
Extra Labor, Repairs, Supplies	366.69	1331.45	1522.93
Insurance on Plant	86.70	152.07	......
Upkeep of Lines and Street Light	731.40	452.73	582.90
Superintendence and undistributed	615.19	912.89	1107.93
Interest on Light Bonds	2540.00	2540.00	2540.00
TOTAL	$8338.04	$11790.28	$11784.59
Net Gain from Light Department	$5583.23	$5088.49	$7545.58
Accounts due and unpaid	......	100.63	......
Net Gain from Water Department	127.85	1056.26	1647.92
Combined Total Net Gain	$5711.08	$6245.38	$9193.50

EXTENSIONS

Total extension expense less credits—Water and Light Departments	$3725.71	$3392.12	$4354.90
Combined total net gain, less extensions	1985.37	2853.25	4838.60
The principal items of the Extension and Improvement account consist of:			
Final payment on Diesel Engines	$2000.00		
Voltage regulator at Power Station	450.00		
Water Plant, including new Pumping Unit		$2750.00	
Electric Plant, Lines and new Meters		1164.23	
Total Fuel Oil consumed—gallons	41784	54499	57065
K. W. Hrs. Generated	328699	445018	454204

Table 5

CITY OF KIOWA, KANSAS—1918 RECORD

Population 1800

Month	Fuel Oil Gals.	Fuel Oil 5c Gal.	Lub. Oil	Cost Lub. Oil	Rep's & Supplies	Labor	Total Operating Cost	Total Receipts	K.W.Hrs. Kiowa	K.W.Hrs. Hardtner	Total K.W. Hrs.
January	4860	243.00	46.2	24.68		315.00	682.68	1347.36	37321	3815	41139
February	4950	247.50	40.1	21.44		475.00	743.94	1120.02	41044	2800	41139
March	5115	255.75	35.4	18.60		475.00	749.35	1172.67	33612	3130	36742
April	4566	228.32	35.2	18.20	16.10	475.00	721.52	1630.06	31339	3245	34584
May	4567	228.33	35.2	18.20		475.00	737.53	1630.06	32340	3245	35585
June	4500	225.00	46.0	24.39		470.00	719.39	1116.29	28582	3730	33322
July	5500	275.00	46.2	24.60		490.00	789.60	1589.94	41412	6000	47412
August	5840	292.00	54.7	29.06		490.00	811.06	1956.99	43613	8850	52463
September	5750	287.50	48.3	22.30		490.00	799.80	1817.58	51394	7850	59244
October	5750	287.50	42.3	22.30		490.00	799.80	1965.38	52394	7530	59924
November	6691	334.55	48.0	25.52	21.00	490.00	871.07	1853.37	61760	6690	68450
December	9030	431.50	48.0	25.60		490.00	967.10	2243.87	67793	7690	75483
Total	67119	3335.95	519.6	274.89	37.00	5625.00	9292.84	19443.59	513617	64575	578192

Repairs for year............................$621.37

Total $658.37

4200 Kw. per month for street lights—free service to City—Fuel Cost	$3335.95
Lubricating Cost	274.89
Repairs and Supplies	658.37
Labor	5625.00
Total manufacturing cost	$9894.21
Net cost per K. W. H.—$9894.21 divided by 578192..	1.71c
Cost of street lights	861.84
Cost Pumping Water	238.20
TOTAL REVENUE, 1918	$19443.59
NET OPERATING COST	9894.21
GROSS PROFIT	$ 9549.38

Cost of Plant—$52,000.00.
Pumping Water—1160 KW. per month.

120 HP Diesel Installed—1913.
250 HP Diesel Installed—1916.
225 HP Diesel Installed—1919.

Population, 1800; Hardtner, 800.
Total Bonds—$115,000.00.
Valuation—$1,013,000.00.

Average return per K.W.H. $0.0336.

N.B.—If City paid cost for street lighting profits would increase in $4171.22.

Fixed charges: 6% interest; 5% depreciation,
1% insurance on $52,000.00........ 6240.00

NET PROFIT..................$3309.38

Table 6

STATION OPERATING COSTS FOR FOUR YEARS ENDING APRIL 1ST, 1919

ACCOUNT	1st Year	2nd Year	3rd Year	4th Year
Wages	$2,037.87	$1,639.79	$1,939.90	$2,314.85
Superintendence	146.00	70.00	141.50	295.00
Fuel Oil	872.01	1,227.03	1.711.76	2,418.37
Lubrication	228.35	278.98	265.97	381.89
Supplies and Incidentals	342.42	343.96	188.51	208.16
Maintenance Buildings	1.20	24.87	.75	12.97
Maintenance Engines	325.31	291.74	215.94	59.97
Maintenance Auxiliaries	55.01	75.99	31.10	113.56
Maintenance Station Electrical Equipment	15.10	7.88	3.00	40.74
Interest on Station Investment	742.10	660.00	960.01	1.141.20
Depreciation Station Equipment	1,151.16	1,009.95	1,486.65	1,887.30
Totals	$5,916.53	$5,630.19	$6,946.09	$8,874.01
Kilowatt Hours Output	121,010	195,185	230,835	251,944
Cost Per Kilowatt Hour at Switchboard	$0.0489	$0.0283	$0.0309	$0.0352
Average Load Kilowatt	13.8	22.3	26.2	28.2

Table 7.
LIBERTY MILLS, SAN ANTONIO, TEXAS

Fuel Oil, 14 gal. per hour for 7200 hours at 5c gal		$5040.00
Lubricating Oil:		
Cylinders, 5 gal. per day at 75c	$1125.00	
Case, 50 gal. every 90 days at 75c	150.00	
Compressor, 1 quart per day at 19c	57.00	1332.00
Attendance: two engineers at $1200.00 each		2400.00
Repairs and Supplies		1194.00
Water and Waste		200.00
Total		$10166.00

Average: 600 bbls. per day for 300 days or 180,000 bbls.
Operating cost per bbl. $0.05647.

In Table 5 we have the complete 1918 operating record of the city of Kiowa, Kansas. This record is very complete and shows a reasonable net gain over and above the gross expense. The town originally used steam power, burning oil under boilers, but because of the excessive fuel cost, the plant operated only from dark to midnight each day.

Again in Table 6 is shown how the real small town can maintain its own plant and operate successfully. In this case the city of Manilla, Iowa, of less than 1000 population, operates two 120 H.P. units, the first of which was installed in 1915 and the second in 1918. A noticeable feature of this record is the low load factor, yet a K.W. is produced at a gross cost of approximate 3c.

Deviating somewhat from the manufacture of electricity, we have in Table 7 a 300 day operating cost of the Liberty Mills of San Antonio, Texas. This plant produces 600 barrels of flour per day at an operating cost of 5.6c per barrel. Fixed charges are not included in this record. An example of high repair cost is manifested here, since this is a plant where hard water caused the cracking of several cylinder heads. Treated water is now used and the trouble has ceased.

In conclusion the writer wishes to state that the Diesel engine is more than holding its own in competition with steam plants and it is a rare occurrence to hear of a steam plant replacing a Diesel engine while the reverse is a regular event. At present the towns of Newkirk, Perry and Anadarko, Oklahoma, are replacing steam plants with Diesel engines, these using, gas, oil and coal fired boilers respectively.

THE 100-INCH HOOKER REFLECTING TELESCOPE OF THE MOUNT WILSON OBSERVATORY.

By Francis G. Pease '01*

The heavens and their attendant sun and stars are just as real and vital as any of our so-called "useful" things of earth. Remove them and we would be without heat and light and without boundaries and without time. They are not to be thought of as distant and unconnected, but as in our immediate presence at all times even as are lands and seas. As such real objects therefore we are using every means in our power to determine their true relative positions in space, to find what they are made of, at what speeds they ae traveling and to determine their age, for worlds have life histories even as men and we find them at all stages of life. All that mechanical ingenuity can devise must be applied to the problem for it is utimately with mechanical things that we must work to attain realities in any of the arts or sciences. The observatory of today resembles any other form of business, there are plans laid, machines devised and built and the whole run on schedule time. Problems are attacked in the same manner; one investigates for example, the problem of Light Absorption in Space in much the same manner that one would undertake the problem of Lubrication. In the former one studies the luminosity and emission of the radiating body and the relative absorption of the various radiations by various thickness of the ether. In the latter one considers thickness of films, pressures, viscosities, and some unknown chemical and atomic action of the material in contact. Since it is only by the radiation received from the stars that we can make contact with them, the principal instruments in use are those for gathering light and analyzing its composition and behavior; these are the telescope and the spectrograph. To interpret these actions experiments are carried on in the laboratory under various physical, chemical or electrical excitations to determine which of them is the one acing in the star.

The most powerful of all telescopes thus far constructed is the

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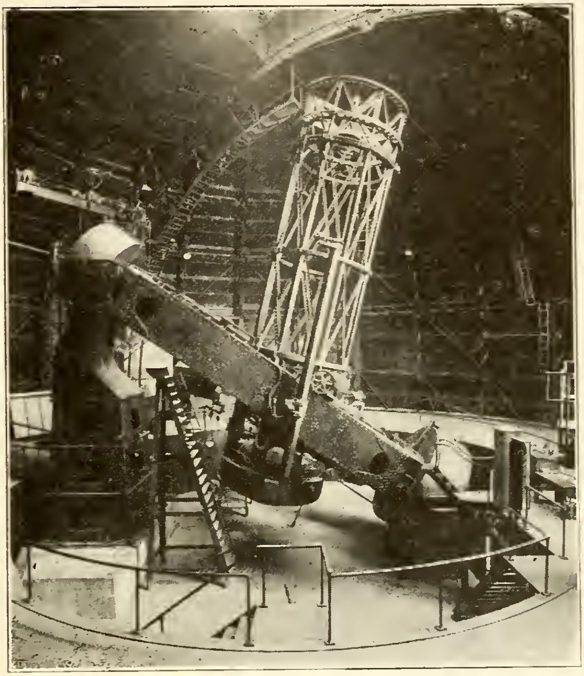
*Astronomer in Charge of Design, Pasadena, California.

The dome of the 100-inch Hooker telescope, as seen among the pines on Mt. Wilson. The shutter is partly opened; the small protuberance at the south is to house a Conde spectograph. The peaks in the range are 30 miles distant, indicating the clearness of the atmosphere.

great Hooker telescope of the Mount Wilson Observatory, having a clear aperture of 100.4 inches and a primary focal length of 507.5 inches. The telescope is now in actual use, the daily results proving the value of the instrument to be of the highest order. The resolution of nebulae, the separation of stars in clusters, the orbit determination of double stars, the fineness of detail seen and photographed on the moon and planets, the great increase in speed in stellar work are more than in keeping with the expected results.

The Hooker telescope is of the reflecting type wherein a parabolic mirror converges the parallel beam of light coming from the distant object to a focus. The image given is a real image, just as is given by a camera lens, it can be viewed with an eyepiece or photographed by placing a plate at the focal plane. Except in extreme cases where all the light possible must be obtained, a plane mirror is placed about 6½ feet inside the focal

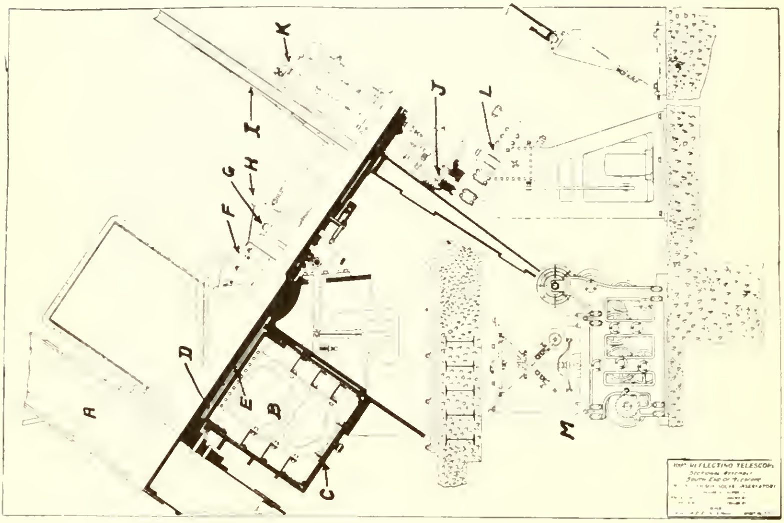


The Hooker telescope, with Cassegrain cage and spectroscope from the west, the latter reached by the tall temporary ladder. The floor outside the railing rotates with the dome; all inside the rail is stationary.

plane and the light turned to the side of the instrument where the focus can be more easily reached. (Newtonian form.)

Auxiliary convex mirrors placed inside the primary focus return the beam toward the large mirror, then to be turned by a plane mirror to the side of the tube to provide a focal length of 142 feet or downward through the polar axis to provide a focal length of 250 feet.

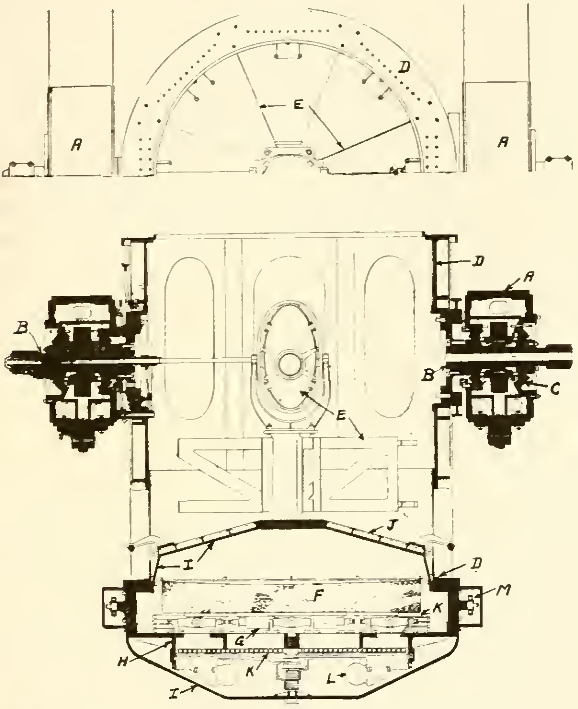
The mirror is 101.3 inches in diameter, 12 inches thick, and weighs 9000 pounds. It is glass, cast in France by the St. Gobain works; it was poured from three pots and its internal structure is irregular, but as the front surface in which the curve is cut is silvered, this affects it only as regards any internal strains altering the curvature; these are eliminated by mounting the glass on large edge arcs supported on knife edges and supporting it horizontally on 12 pads, three of which are fixed, the remaining 9 counterweighted. The glass and its supporting systems lie in a massive steel cell which bolts to the lower end of an open tube 11 feet outside diameter and 38 feet long. The bottom sections of the tube is composed of steel casting rings, columns triangular in cross section, of pressed steed plates, and open panels of steel plate. Two massive castings are built into the section to carry the declination trunnions. The remaining sections, including the "cages" which carry the various auxiliary mirrors, are built of similar steel rings, columns of Shelby tube, corner castings of steel and diagonals of tire channel. Each section is assembled



Section Through Lower End of Polar Axis.

A—South member of yoke.
B—Drum.
C—Tank.
D—Sleeve to increase depth of mercury.
E—South trunnion.
F—Spherical Bearing.
G.—End throat.
H—Graduated circle for setting telescope in right ascension.
I—Worm wheel.
J—Clamp.
K—Right ascension, quick motion gear.
L—Right ascension, quick motion drive.
M—Driving clock.

and then machined as a unit; the cages are interchangeable, fit a tapered ground point on the upper end of the permanent part of the tube and are locked in position by 8 lip bolts controlled by a single handle.



Section Through the Lower End of the Tube and Declination Axes.

A—Side members of spoke.
B—Declination trunnions.
C—Spherical Bearings.
D—Section I of tube.
E—Conde mirror and supporting bands.
F—100-inch mirror.
G—Bottom lever support system.
H—Mirror cell.
I—Cork board insulation.
J—Cover formed of eight leaves.
K—Temperature control pipes.
L—Bottom counter weights.
M—Bearings for silvering fork. Mirror edge support not shown.

The weight of the tube is 35 tons; its center of gravity lies on the declination axis, so that it is always in balance. Some of the various attachments alter this balance, the change in moment is compensated for by the motion of two 1400 pound weights in the large tubes seen at the side. Two additional counter weights are placed under the mirror cell to provide for adjustment about the axis of the tube.

The declination bearings are spherical in shape to allow for any flexure of tube or yoke; these spheres serve to align the axis while the bulk of the weight at each bearing is taken up by two systems of roller and ball bearings, one axial, the other radial; these systems are counterweighted by a series of levers extending downward along the yoke and actuated by a common weight.

The tube is suspended in a massive yoke, the polar axis, 16 feet across and 32 feet long, on the ends of which are trunnions supported by massive bearings. The axis of the yoke lies parallel to the earth's axis and is inclined at an angle of 34 deg. 13 min. to the horizontal, pointing to the north pole of the heavens.

The yoke consists of four members, built of structural steel with a massive steel casting at each end; their weight is 10 tons each and after assembling each was machined at each end; their weight is 10 tons each and after assembling each was machined as a unit. Their average cross section is 2 ft. wide by 4 ft. deep; hollow steel trunnions are bolted on the end members, and to these in turn are bolted the large steel flotation drums. The weight of the moving parts of the telescope is 100 tons. This mass is driven at just such a rate (1 revolution in 24 hours) as to equalize the dirunal motion of the earth, consequently every provision is made to reduce friction to a minimum. To define the polar axis are two spherical bearings, to relieve the friction are two liquid flotation systems, consisting of hollow steel drums fastened to the trunnions, which float in tanks of mercury supported by the North and South pedestals. The drums are bolted at their upper ends and their insides relieved about an inch so that sleeves fastened to the south faces of the tank reach nearly to the upper faces of the drums thus increasing the depth by many inches. The center of displacement of the tanks passes directly through the bolted face of the drums so there is no tendency to twist about the axis. The south drum is 10 feet, 7 inches diameter by feet 10 inches long displacing 60 tons, the north 8 feet 5 inches diameter by 3 feet 3 inches long displacing 40 tons. There is a ball ring thrust bearing at the lower face of the south bearing to define the position of the axis longitudinally. The instrument is driven by a "driving clock" through a worm and worm wheel which clamps to the South Trunnion.

Rapid motions are provided for setting the telescopes in Right Ascension and Declination as well as slower motions to enable the observer to correct for errors in speed, refraction and bad seeing.

The Right Ascension Quick Motion stands at the south end of the axis and its lage gear is keyed directly to the South Trunnion; the Slow Motion worm wheel lies just above this, and is clamped to a ring on the quick motion gear by means of a solenoid operated clutches.

The worm wheel is 200.53 inches in diameter, has 1440 teeth accurately cut on the circumference and so ground that there is no periodic error as great as 1/100,000 inch.

The driving clock is a device in which the speed of a falling weight is automatically governed by a sensitive isochronous conical pendulum, friction being introduced by wipers rubbing on a drum.

The driving clock connects directly to the worm with a double Hooke's Joint to eliminate any periodicity due to the worm and clock shaft not being truly adjusted. The speed of the worm can be altered by the observer by means of a motor mounted on the last shaft of the clock. The declination, quick and slow motions are mounted on the yoke beside the tube and operate on it, the former through a sector, the latter through a long screw and arm. The range given by the two motions is from 30 deg. per minute to 2 2/3 minutes are per minute of time.

The telescope stands on a hollow concrete pier 33 feet high, bringing the intersection of the polar and declination axes at elevation 50 feet.

Since variation in temperature alters the figure of the mirror with consequent distortion of the image the mirror and its cell have been surrounded with an inch of corkboard and means provided to control the temperature within the enclusure. Brine, the temperature of which is automatically controlled by a thermosat within the enclosure, is circulated from a tank in the pier through coils lying under the mirror; fans circulate the air all around the mirro and coils. The brine is heated by electrical coils in the tank and cooled by ammonia expansion coils. Eight interconnected leaves, motor operated, fold open in front of the mirror when in use.

It is necessary to resilver the mirror twice a year; to do this a massive fork passes up through an opening in the top of the pier and transfers the mirror in its cell to the silvering room in the pier. The silver coating is deposited chemically from a liquid solution and after drying is burnished with a large chamois skin pad and rouge.

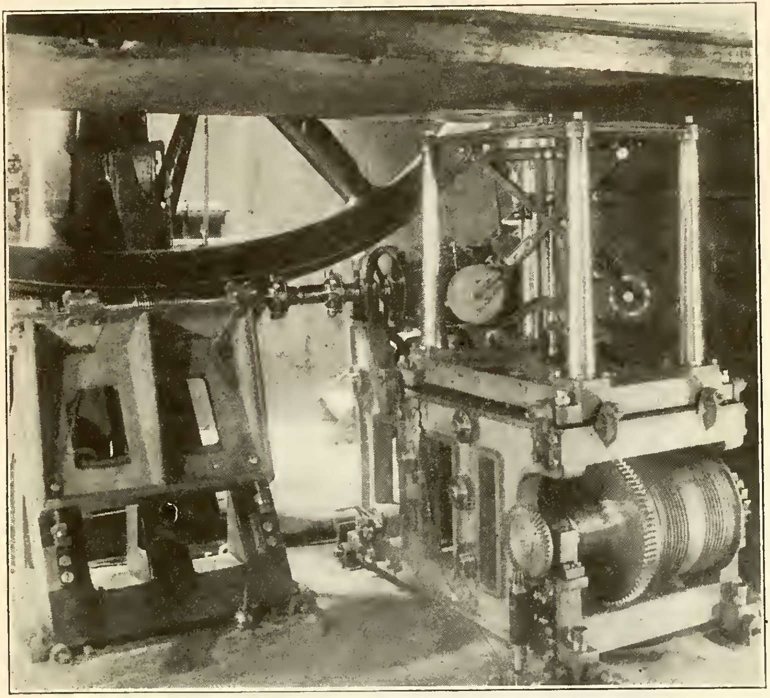
The housing is a dome 100-feet in diameter and 100 feet high, all above 28 feet rotating on tracks on the lower fixed part. The dome is of structural steel and sheathing throughout, and double walled, to insure more uniform temperature inside. The upper part is carried on 28 trucks with conical wheels and is traction driven by two 7½ k.w. moters at opposite points. Its weight is 550 tons, while that of the fixed part is 250 tons. A slot 20 feet wide extends from elevation 44 feet to the peak of the dome, providing an opening through which the telescope is pointed, and is covered with a shutter formed by two halves moving along horizontal tracks.

To reach the primary focus of the telescope an observing platform is placed across the shutter opening, which travels up and down the main girders, its level being automatically regulated at the hoisting drum. To reach the secondary or Cassegrain focus on the north side of the tube, there is a platform which travels across and up and down the south face of the North Column.

All motions of the instrument and dome are motor driven and nearly all the circuits are "remote control." The settings can be made from a deck just beside the south pedestal and from auxiliary controls at the three foci. There are altogether 40 motors used in the dome, with an aggregate of 50 H.P., and about 14 miles of wiring.

A ten ton crane travels along the main girder opposite the shutter opening and handles all cages and instruments about the telescope.

The telescope is situated upon Mount Wilson near Pasadena, California, 5800 feet above sea level, where the atmosphere is free from the lower clouds and dust and where it can be oper-



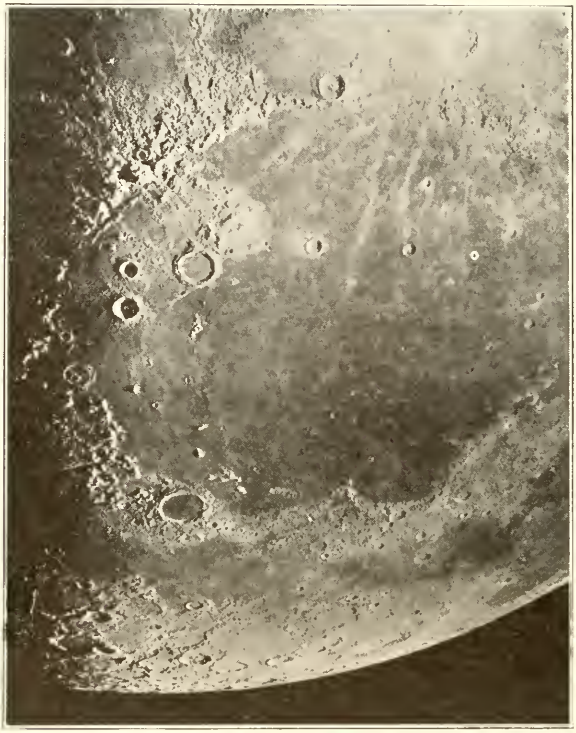
View of driving clock and lower part of 200-inch worm wheel. Worm connects to clock with double Hooker joint. Joint is not shown correctly connected. Control yokes should be parallel. Worm wheel is hollow and of cast iron. Clock delivers 1-25 H. P. to the worm wheel.

ated a large part of the year to excellent advantage.

As an illustration of the work of the telescope, a photograph of the moon is shown in the Figure on page 316. This is from a negative taken at the Cassegrain focus of the Hooker reflector, Sept. 15, 1919, and are by far the sharpest photographs of the moon yet made.

Looked on as an engineering problem, no serious difficulty was met with in the construction of the Hooker telescope and a machine of double the aperture might well be built before one was seriously at the limiting factors of the materials of today.

The task laid out for the great reflector already stretches into many years, but it is expected that the remarkable facts obtained with it will lead to the building of other great instruments, though not necessarily of the same type, to assist in this necessary and vital work.



Photograph of a portion of the northern section of the moon just before the last quarter. Taken September 15, 1919.

X-RAY FINDS FLAWS.

The difficulty of detecting flaws and the presence of foreign bodies, of a metallic or other nature, in built up mica which is used for insulating purposes, has caused one large manufacturing company to install an X-ray testing outfit for this purpose. With this apparatus foreign objects, such as pins, bits of wire, etc., as well as the weak or thin spots in the mica itself can be readily detected. The detection of these flaws before the mica is actually used for insulation purposes is highly important, as much damage, and loss of time and money due to faulty mica are averted. Other materials can be examined in the same way.

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ELECTRICITY, THE WONDER WORKER.

By Walter M. Seyferlich '20.

To present in the time available an adequate story of what electricity is doing, is difficult because of the multitude of fields that have been invaded by electricity, the fields that have been created by electricity, and because of the almost limitless applications in each field. Its history and its statistics, while important and interesting, must be omitted to make way for the indispensable practical things in which we are intensely interested at this time.

In order not to get confused or to overlook essential points, we will consider the work of electricity by divisions.

1. Things done better by electricity than they were done before.
2 Things that are more largely done now that electricity has been applied.
3. Things that can only be done electrically.
4. New developments that are claiming the minds of engineers and scientists.
5. Electricity in the life of the average individual.

Under the 1st division are placed the many things that were and are still done by water power, by steam or other methods, that are now more commonly and much beetter done by electricity.

Take for instance local transportation, the trolley cars, subway and elevated trains. How inadequate or impossible horse cars seem now. Imagine steam locomotives in the subway; note the 10 car trains with 1 1-2 minute headway and quick acceleration necessary to maintain schedules. Interurban cars maintain rapid and frequent service, and have relegated to the attic, the old two steam trains a day on the local railroad line.

Mine and quarry haulage is now usually electric. Narrow gauge tracks and low trollew wires are installed and the electric locomotives are low compact machines that pull long trains of ore, coal or gravel cars. Transfers of material between receiving departments, various shops and shipping departments of large industrial plants are often accomplished by means of narrow gauge electric systems.

Electric signalling is a great forward step over previous pneumatic, hydraulic or pull wire methods. Fast trains are possible because electric signals make them safe.

Ingenious interlocking decises, answering signals and other precautionary measures are readily worked out electrically that would be difficult or impossible by any other means.

Gun fire control and many other functions on battleships are carried out with certainty and precision by electric signals. Ordinary door bells, buzzers, etc., are simple examples of this work.

Machinery of almost every description is now actuated by electric motors because the power can be brought to the machines through small inert wires instead of through power wasting line shafts, rope drives or belts. The machines can be started, varied, stopped or reversed so readily by a small handle that the readiness of control alone has brought about the use of thousands of motors. Each machine calls for only the power it actually uses so that independent operation for overtime work is not an extravagance.

Some industries use almost no other means of distributing power to various machines, a notable one being the industries for in all phase of spinning, weaving, dyeing, printing, etc., electric motors do the work. Shoe manufacture, cement production, wood working plants the rubber industry and automobile manufacture are all electrical and there are hundreds of other industries wholly or in part motor driven.

Where machines are inaccessibly located or widely scattered on co-related work the remote control afforded by electricity does away with cumbersome rods, ropes, signal men, etc. An example of what this means may be seen at any modern canal lock where a great number of closely related movements are carried out from a central point which is virtually the nerve center for the whole system.

Cranes of various types such as bridge cranes in shops, gantry cranes in yards, ore and coal bridges and ore unloaders, afford good examples of remote electrical control. The shop bridge crane has high and low speed hoists, trolley motion across the shop and bridge motion lengthwise employing in all, usually four motors. The operator in his cab has all these motions under handy control while the motors themselves are placed wherever handiest to do their work.

Things that are processed or produced by means of high temperatures, are now being better done by electric resistance or by arc. The alloying of special steels, the melting of refractory substances, and the welding of materials are in this field.

By these methods, metals and substances are secured in the pure state, enabling studies to be made of their true characteristics. An attractive field for electric heating is in the drying of enamels such as are used on automobile bodies, and this work is rapidly being electrified.

But the great thing that is done so much better than of old as to hold no comparison, is *Lighting*. Indoor and out-of-door residence, public buildings, factories, or mines, they are all alike lighted by electricity. On land and sea, signal, safety and comfort lights are electric. Ornamental lighting has reached a high degree undreamed of before, and searchlights, head lights, pocket lights and a hundred other kinds indicate, if you stop to think, that we owe much to electricity for fighting off that bugbear of our forefathers and of our childhood—the dark. Special lights have been devised that imitate daylight so closely, that colors of all kinds may be accurately matched—a light of great value in dry goods stores, art shops and dye plants. Lights high in actinic power have been devised for photographic work, and intense lights of a very concentrated nature are made for projecting pictures. The list of special lights is long and is being added to rapidly.

In the old days of mechanical transmission of power, only those water powers to which raw material could be easily transported were developed as power producers. i. e., only water powers in or near communities or in places where roads and towns could be built were available. Now, thanks to electricity, any water power no matter how remote or inaccessible, can be made to contribute to our needs.

Electro-metallurgy and electro-chemistry produce in commercial quantities aluminum which not long ago was a prized curiosity, carborundum and like abrasives, calcium carbide from which acetylene gas is released by contact with water while innumerable gases, compounds, chemicals, metals and metal alloys which heretofore were produced only in laboratory experiments or not at all, are now readily available for practical work.

An attractive new field is the fixation of atmosphereic nitrogen in such a way as to produce nitric acid which is so necessary in the production of explosives and in the useful arts. The formation of nitrogen compounds for fertilizers is a part of this work now in successful production and the thing that appeals to the layman in this connection is the abundance and accessibility of the raw material—the air.

Mining operations are greatly expedited and enlarged by electric power. In the cutting of coal, the hauling and elevating of coal and ores in the preliminary manipulation of the material and in unwatering workings, electricity is now the master hand.

The rapid and economical handling of bulk freight especially the free flowing types is largely now an electrified industry. Belt conveyors, bucket elevators, coal and ore bridges, or unloaders, grab bucket machinery, reclaiming devices and car dumpers are remarkable examples of ingenious application of electric motors.

The derivation of power from fuel has been carried to the highest point of efficiency in the great direct connected steam turbine electric generator units which develop as much as 50,000 h. p. in a single machine, and still larger units are now under construction. These units use only 9-10 of a pound of coal per horsepower hour. What this means, is that one such machine would nicely light 100,000 homes, or it would run 3,000 ordinary trolley cars. The cost of electricity in such a steam plant is as low as the cost of hydro electricity when all charges are considered.

Now we come to the astounding and seemingly impossible things that electricity has presented to us and which were never possible or even dreamed of before its advent. Modern communication is a good example of the work of this Aladdin's lamp that we call electricity. Time was when a letter sent and a letter in reply was the only means of communication unless by messenger. Then came the telegraph and telephone with tangible metallic wire connections from sender to receiver, which at last gives us a straw to clutch at in struggling to understand. More recently has come that astounding means of communication known as radio-telegraphy with nothing tangible between the parties. This at once provided a means for communication between ships and with stations.

Military and naval operations and commercial transactions are greatly aided by wireless communication.

What are virtually controlled groups of electrical groups of electrical explosions released by the sender's key, produce waspish sounds in all properly arranged receivers within the range of the waves. It must be borne in mind that there is no similarity between the two sounds. This has been followed very recently by practical long distance radio-telephony which is even more wierd and mysterious than radio-telegraphy because the actual sounds are faithfully reproduced even to voice characteristics. In other words, two people can hold conversation across a continent or an ocean or both in normal recognizable voice tones without any physical or tangible connection than the earth itself.

There are many operations carried out that were impossible otherwise. Many elements can only be separated or combined by electrical means, hence our knowledge concerning many gases and metals has been greatly augmented. One of the very practical fields with which we are familiar is electro-plating or electro deposition of metals as it is called. This application of electricity is used in three ways:- 1st, as a means of securely covering one metal with another; 2nd, to secure chemically pure metals, and 3rd, to secure sheets of metal of extreme thinness.

Another thing that has been made possible by electricity is the peering into and through opaque objects by means of the so-called X-Ray. Its use in surgical work and for medicinal purposes is more or less familiar to you all and stands out as one of the most astounding of electricity's wonder works.

The storage of power for future use was made possible by the electric storage battery which hoards within itself for long periods energy that can be drawn upon at a time or place that is convenient or expedient. This principle is widely used and in all degrees from the little ignition battery to the gigantic batteries used by a great railroad system to take up energy when work is light and to feed it back into the system when work is heavy. The storage battery does not actually contain any electricity but its chemicals are put in such a state by electricity that when allowed to fall back to the normal condition they produce a somewhat lesser amount of electricity. A good example of the practical use of electric storage is found in the submarine which when running on the surface by means of engines, charges its batteries against the time when it must submerge and stop its engines, for no engine, steam, oil or gas, can work against the back pressure of submarine navigations.

When submerged the propellers are driven by electric motors deriving their power from the storage battery. Electric cars, autos and trucks are also a familiar application of this valuable feature of electricity.

The major characteristic of electricity, the novel ability that has placed it so far ahead of all other powers and has made its use so universal is—ease of transmission. Electric power can be transmitted to great distances with very little loss and over paths that are comparatively inexpensive. This feature makes possible the use of electricity in your homes, makes possible the use in cities of hydro-electricity generated at water power plants perhaps several hundred miles away and makes possible the trolley cars and other electric trains and the lighting of our streets. Frequently several water power and several steam plants are tied together in a system to supply many cities and manufacturing centers. Thus the Schaghticoke Falls, 38 miles away, together with two steam plants in the city furnish all the power for the trolleys, city lights, city pumps, light and power for the homes and motor-drives for thousands of machines in the factories of Schenectady.

Niagara power is transmitted as far west as Syracuse and in the western and southern states, systems several hundred miles long are common.

The great new developments that are holding the minds of engineers are the electrical operation of railroads and the electrical propulsion of ships.

In the railway field much progress is in evidence. The electrification of terminal centers came first as exemplified by the N. Y. Central, N. Y., N. H. & Hartford and Pennsylvania Terminals in New York. Electrification of main lines is now being carried out in many places with marked economy and reliability. Notable examples of recent trunk line electrification are the Butte, Anaconda and Pacific Railway, 114 miles; and the Chicago, Milwaukee & St. Paul, 650 miles. Conservation of energy is a marked innovation on these roads inasmuch as the braking is not done by friction brake shoes except to a very small extent, but rather by making the motors generate electricity while being driven by the momentum of the train; thus, while holding the train to a certain speed on a grade or coming to a stop, the electric locomotive turns back into the system quantities of electrical energy. Thus, a train running down a long grade very materially helps to haul another train up some grade perhaps a hundred miles away. In some cases as much as 2800 h. p. is turned in for considerable periods or enough to light 52,000 40-Watt lamps. This shows something of the energy wasted by brake shoes in ordinary braking to say nothing of wear and tear on shoes, tires and rails.

The locomotives on these roads weigh from 280 to 300 tons with consequent high hauling capacity. Another point not commonly understood is that electric locomotives work about 22 hours per day or three times as many hours as the steam locomotive, so that an electrified road can be appreciated when we consider the great steam power station such as before mentioned against a little steam engine and boiler on each locomotive, and in addition the electric system makes water power available for pulling trains.

The adoption of electric propulsion for ships is unique in its rapid growth from small boats through larger to its present state of adoption in the largest of ships. The first example was the U. S. Collier "Jupiter," a ship of 20,000 tons, which has been in operation two years with most gratifying results. There is now under construction at the N. Y. Navy Yard, the 32,000-ton battleship "California," which will be electrically driven at 27¼ miles per hour (22 knots) by 37,000 h. p. at the propeller shaft. It will have two steam turbines driving electric generators which in turn drive four motors each on a propeller shaft. The economy of this system lies in running the steam turbines at the high speed which is for them the most efficient, and running the propeller at the low speed that gives them their greatest efficiency. Many other advantages result, such as reduced weight and space for propelling machinery, nicety of control and economy at speeds lower than maximum.

In line with the wireless transmission of messages, scientists and engineers are endeavoring to transmit power or impulses in the same way. This has already been done sufficiently to actuate the steering gear and power of torpedoes, and the like. The impulses are very weak and so far are only able to set in motion internal functions of the craft or torpedo, to steer, start, or stop the same. It is not beyond the realm of possibility that we may see the wireless transmission of aactual power—a theme that leads our imagination into fascinating channels.

Just how largely the average person is affected by the manifold activities of electricity, it is hard to estimate, but we are liable to become so accustomed to its ministration that we do not appreciate how much we are dependent upon it.

Electricity reaches more individuals by means of its lights than by any other phase. We flash our house lights on and off without a thought of the far away source or the intricate system that insures their readiness. We give the street lights not a thought; they are a matter of course. The domestic heating and cooking devices also come close to the individual. The flatiron, the toaster, the percolater, the pad and many other handy and comfortable devices are made so by electricity. The telephone is practically indispensable to the individual as is proven by its great and rapidly increasing use. Domestic motors now drive laundry machinery, victrolas, sewing machines, fans and the boys' mechanical toys. The trolley takes you down town, you have an electric massage and take the elevator to your office. There you have again the telephone, lights, fans, buzzers and dictaphone. The products of electrical energy are all about you. Your morning paper was made by electric motor, bleached by electrolysis, printed by electric motor and illustrated by electrotypes. Your 'phone and typewriter are nickelplated, your wire baskets are electric-welded and so it goes. Almost everything you use and almost everything you do, is or was affected by electricity.

In general, probably the most striking thing about electricity is its versatility, its quality of turning its hand to thousands of widely divergent uses. It may be a kitten's paw or a giant of giants. From the magneto in your car to the driving heart of a great railroad system is a far cry but easily encompassed by electricity. The tiny surgical lamp and the great battleship searchlight are as one in simplicity. It warms the baby's milk bottle and it melts tons upon tons of the most refractory ores. It drives the dental drill and it drives the ship's propeller.

It transmits the energy of the human voice and the energy of the roaring waterfall with equal ease. Yet in all its many-sided applications it is controlled with ease and certainty. The ponderous lock gates of Panama are moved by a lever the size of a cigar. Rock cliffs are demolished by blasts set off at the touch of a push-button.

The titanic crane picks up the 200 ton gun and places it as gently in its carriage as a mother does her babe; every move being under the postitive, instant and delicate control of the crane man's fingers.

What it is we do not know, how to use it we do know. What it has in store for us we cannot even guess but we have found it to be the most valuable servant of mankind.

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DOING FAIRLY WELL.

The United States has only six per cent of the world's population and seven per cent of the world's land, yet produces:

20 per cent of the world's supply of Gold
25 per cent of the world's supply of Wheat
40 per sent of the world's supply of Silver
40 per cent of the world's supply of Iron and Steel
40 per cent of the world's supply of Lead
50 per cent of the world's supply of Zinc
52 per cent of the world's supply of Coal
60 per cent of the world's supply of Aluminum
60 per cent of the world's supply of Copper
60 per cent of the world's supply of Cotton
66 per cent of the world's supply of Oil
75 per cent of the world's supply of Corn and
85 per cent of the world's supply of Automobiles.

—The Fidelity Journal.

BOOK NOTES

Broemel, Louis. *Sheet Metal Worker's Manual*—Drake, 1918.

This work "describes the machinery and tools used in sheet-metal working, their applications and operation. A considerable section is devoted to a course in sheet metal work and pattern drafting, and there are chapters on welding by various processes. The book is well illustrated with line drawings." (Pratt.)

Brown, Nelson Courtland. *Forest Products*—Wiley, 1919.

"Embracing the principal commercial features in the production, manufacture and utilization of the most important forest products other than lumber in the United States." (Subtitle.) Chapters on wood pulp, tanning materials, veneers, naval stores, distillation, charcoal, boxes, cross ties, poles, posts, mine timbers, shingles, maple syrup, rubber, dye woods, excelsior and cork. By the Professor of Forest Utilization, New York College of Forestry. (Book Review Digest.)

Campbell, Lorn. *Oxy-acetylene Welding Manual*—Wiley, 1919.

"A practical textbook written by an officer in charge of welding instruction in the Ordnance Department, U. S. Aarmy." (A. L. A. Bkl.) "Covers methods for welding cast iron, malleable iron, steel, brass and aluminum, with short chapters on oxy-acetylene cutting and carbon burning. Provided with brief glossary of terms peculiar to the industry." (Pittsburgh.)

Collins, Sidney Hoare. *Plant Products and Chemical Fertilizers*—Van Nostrand, 1919.

"The raw materials of agriculture are often the waste products of the other industries, and the produce of agriculture again forms the raw materials for other industries. The following pages attempt to pick up the story of those industrial waste products which are useful as fertilizers, and carry it on through the soil and crops, until new products are available for industrial uses." (Preface.) The four parts of the book are devoted to

Fertilizers, Soils, Crops, and the Production of Meat. In addition to references given at the end of each section there is a general bibliography. (Bk. Rev. Dig.)

PARTINGTON, JAMES RIDDICK. *Alkali Industry*—Van Nostrand, 1919.

The sections of the book take up: the salt industry; sulphuric acid; natural soda and the Leblanc process; the ammonia-soda process; electrolytic processes; chlorine and derived products; nitric acid; ammonia and ammonium salts; the oxidation of ammonia; utilization and economy of sulphuric acid; potassium salts, iodine, magnesium.

"The treatment is certainly novel and it appears to the present reviewer to be successful in that it provides a book which is far more readable than the ordinary text books on the subject. There are numerous points of detail which might be criticized adversely, and to this extent it fails to give an accurate picture of the industry. But such criticism is of minor importance as compared with the potential power of the work to stimulate interest, and it should certainly be placed in the hands of every process manager and chemist and of all students who wish to enter chemical industry." Nature 102:21.

ROSS, JOSEPH. *Waterproofing Engineering for Engineers, Architects, Builders, Roofers and Waterproofers*—Wiley, 1919.

"The first complete work on the subject. The author states that early in 1914 he began a 'systematic search and diligent study of existing literature, finding the field large but the harvest surprisingly small. . . that the subject seems to be regarded as a sort of necessary evil in engineering, to be overcome as best theevigency of the cast would permit.' Much of the text is therefore based upon his extensive personal experience and research. The need and function of waterproofing are clearly explaied and the different systems, materials, implements and machinery described. There are chapters on impervious roofing, the waterproofing of expansion joints in masonry, methods of testing, specifications, practical recipes, cost data, and practical tables." (N. L. P. L. New Tech. Books.)

STILL, ALFRED. *Principles of Transformer Design*—Wiley, 1919.

"Considers the subject from the theoretical viewpoint. Method of presentation conforms to the author's course in electrical design for senior students in the school of Electrical Engineering at Purdue University." (Pittsburgh.)

SUVERKROP, EDWARD A. Comp. *American Machinist Shop Note Book*—McGraw-Hill, 1919.

"A collection of articles written for the American Machinist by practical men, covering a wide variety of machine-shop activities, and giving the solutions of problems that have arisen in machine-shops the world over." (Brooklyn.)

WEGMANN, EDWARD. *Conveyance and Distribution of Water for Water Supply*—Van Nostrand, 1919.

"Aqueducts, pipe-lines and distributing systems, a practical treatment for water-works engineers and superintendents." (Subtitle.) The first extensive work on the subject dealing fully with the essentials and many details not treated in other works." (A. L. A. Bk. List.)

The Armour Engineer

The Quarterly Technical Publication of the

Armour Institute of Technology

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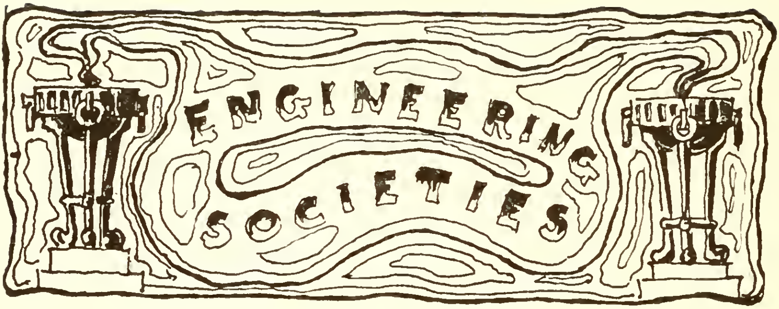
MR. F. U. SMITH.

In the resignation of Mr. Frederick Urling Smith as Comptroller of the Armour Institute of Technology, there comes to mind many evidences of the growth and development of our city, especially in educational lines within the last thirty years.

Mr. Smith was at the right hand of Mr. Philip D. Armour when he was devising means and ways for helping the youth of the middle west by creating the Armour Institute. Mr. Smith met Mr. George W. Childs who had influenced Mr. Drexel of Philadelphia, Mr. Smith's former home, to establish an institution like the Pratt Institute of Brooklyn and the Cooper Institute of New York City. He heard these men discuss the matter of education with Mr. Armour, and he became closely allied with the new institution.

For twenty-five years Mr. Smith has appeared upon the platform at Commencement time with his annual report as Comptroller. He had been a model of courtesy, gentility, wisdom and loyalty in the presence of thousands of students. The Institute itself would feel bereaved if it were not for the fact that he goes to his rest or pleasure as he will, at the close of the current year, and he goes in perfect health of body and mind to enjoy with his good wife many recollections of his labors on the Executive Council of the Institute, and especially the influence he has had and the participation which has been his in the new plans for the Armour Institute of Technology, when its walls shall echo with the tread of the thousands of students and teachers who shall throng its new and larger home at Windsor Park.

DR. F. W. GUNSAULUS.



THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President	Ellis C. Cook
Vice-President	I. J. Bready
Treasurer	H. C. Peterson
Secretary	Wm. N. Erickson

At the last meeting of the A. S. M. E. some very interesting talks were given. Mr. S. H. Webster talked on Tractor Carburetors. One hindrance in the use of the tractors is the trouble caused by dust getting into the carburetors. Mr. Webster described various methods of eliminating dust being carried into the carburetor with the air.

Mr. M. Marks discussed and described the erection of a foundry for the Sampson Tractor Co. at Janesville, Wisconsin.

Mr. G. E. Peterson talked on ventilation and indirect systems of heating.

Mr. A. Tabachnick talked upon the complexities of industry. As an illustration he discussed and described the various details of construction and processes of manufacture of a mower knife in the harvesting machine of the International Harvester Co.

Mr. R. B. Middaugh gave a general talk which was very interesting, on the methods employed by the construction department of a large packing house. Mr. Middaugh has had considerable experience in construction and knew his subject thoroughly.

At our next meeting the election of officers for next year will be held.

The A. S. M. E. has had a very successful year and will no doubt continue to have success next year. The society has accomplished a great deal that will be of help to the society next year. The most important accomplishments brought about were the holding of meetings during the day, the change in policy of conducting meetings and the organization of a Freshman-Sophomore branch of the society. Our policy of conducting meetings during the day has assured a large attendance at all of our meetings. Our method of conducting meeting this year has resulted in every member giving talks before the society. The organization of the Freshman-Sophomore branch was the result of the active interest displayed by the Freshmen and Sophomores in the A. S. M. E.

WM. N. ERICKSON,
Secretary.

FRESHMAN AND SOPHOMORE BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

President ....Jeff Corydon, Jr.
Vice-President ....Otto Kuehn
Secretary ....G. Donald Wetherbee

At a former meeting, it had been suggested that we have Professor Gebhardt speak to us at some early date. He was asked, and was present at our meeting March 16th. There was a large attendance at this meeting, apparently because it had been publicly announced that no member would be called on for an extemporaneous talk according to our custom at these meetings.

Professor Gebhardt impressed upon us the importance of our engineering society, and mentioned the fact that the successful Alumni of Armour Institute are the ones who were active members of these societies while in school. Advertising is a necessity today, and it applies to the services of engineers as well as to articles of merchandise. Men should mix and become known, and A. S. M. E. offers opportunities to meet the biggest engineers in the country. He said that no subject in our course was more important than our A. S. M. E. meetings, where a man can get up and tell people what he knows in a clear and convincing manner. If one stays by himself all his life, he will never get any place, no matter how much he knows or how hard he works. Moreover, a big crowd at a meeting is better than a small one, to supply ballast if nothing else; to give the speaker some one to talk to.

Professor Gebhardt also gave a brief outline of the purposes of the parent A. S. M. E., of which we become Junior members automatically upon graduating.

When he had concluded, he was given a vote of thanks, and as there were still several minutes left, Rudolps Werner was asked to speak. He told us about refrigerator machines, especially the kind which are built by his father in Australia. He also described the different types of refrigeration equipment used in Australian fruit storage plants.

G. D. Wetherbee.

THE ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF ELECTRICAL ENGINEERS.

Chairman	W. M. Seyferlich
Secretary	H. D. Stevers
Treasurer	J. Smely

During the months of March, April, and May, many meetings were held at which interesting papers, addresses, and discussions were presented, several of which were illustrated lectures, accompanied either by lantern slides or motion pictures. Of the eight meetings accounted for below, three were called by the Local Branch of the A. I. E. E., while the remaining four were arranged by other organizations, but were heavily attended by members of the A. I. E. E.

On Thursday, March 4th, a special business meeting of the Local Branch was called for the purpose of making definite arrangements regarding the group-picture of that organization, for the Cycle of 1920. Among the twenty-five electrical students that attended, were several visitors, who, after holding a discussion with the Chairman, became interested in the A. I. E. E., and filed application for membership in same.

The next meeting of the Local Branch was held jointly with the A. S. M. E., and was attended by more than eighty students, as well as several members of the faculty. The meeting was agreed upon by Messrs. Cook and Seyferlich, and was presided over by the latter. This meeting, which proved to be one of the most interesting of the year, was called on Thursday, March 25th, with Mr. J. W. Naiman '21, as the principal speaker of the day.

Mr. Naiman's subject was "The Application of Electricity to Mechanical Measurements," a very broad and interesting subject, which is claiming the attention of many noted scientists and engineers, throughout the world. Using one of his own devices for Fluid Flow Measurements and Control, as an example, Mr. Naiman pointed out the great inherent advantages in electrical methods of making such mechanical measurements. Particular emphasis was placed on the high degree of accuracy whih may be obtained in a comparatively simple manner, electrically. With the aid of a crude working model, as well as patent office drawings and lantern slides made therefrom, Mr. Naiman showed how his invention may be used to measure and control, the steam flow in any system utilizing steam. A more extensive account of Mr. Naiman's Meter and its application to flow measurements, appears elsewhere in this publication.

Through the efforts of Professor Freeman and Chairman Seyferlich, a second speaker was obtained on short notice. Following Mr. Naiman's lecture, Mr. R. C. Newbury, of the Denver Gas & Electric Light Co., gave an extemporaneous address on the subject "Public Utilities, and the Future Prospects for Engineering Graduates." Immediately after the adjournment of the meeting, Mr. Newbury held personal interviews with those students interested in his propositions, and enlightened those who had questions on Public Utilities, and Public Utility Corporations.

At a meeting of the Chicago Section of the A. I. E. E. and the Electrical Section of the W. S. E., many local members had the excellent opportunity of hearing Mr. O. B. Blackwell, Transmission Development Engineer of the American Telegraph and Telephone Co., on the subject "Transmission of Intelligence." The meeting was held in the W. S. E. rooms in the Monadnock Bldg., on Monday evening, Harch 29th. Mr. Blackwell discussed in a very interesting manner, the development of telephone engineering in its newest aspects, and many of those present left wtih a much broader view of telephone engineering as it is today.

A very interesting meeting was held in Science Hall, on Tuesday, April 6th, and although called by the Mechanicals, was open to other students. More than a hundred and thirty students attended this meeting in order to view four interesting reels of motion pictures on the subject, "Twist Drills, and Their Proper Use." Besides holding the attention of every seudent present for the full duration of forty-five minutes, the pictures were of a very instructive nature, and in substance matter, provided a regular course in twist drill manipulation, and machine shop practice. One of the greatest and most desirable features of the exhibition was the excellent manner in which the pictures were shown. The four reels were shown as stated above in exactly forty-five minutes, and there were no interruptions to promote dis-interest at any time. The machine itself was very unique in that it was driven by a constant speed electric motor, and therefore in changing over from one reel to another, very little time was required in stopping and starting. The machine was also encased in fireproof casing, which, by the way, would justify its use in most any lecture room without any appreciable danger.

On Tuesday, April 20th, an illustrated lecture, accompanied by lantern slides from the General Electric Lecture Service Bureau, was presented by Chairman Seyferlich before the Local Branch of the A. I. E. E. The subject was "Electricity the Wonder Worker," and the text of the lecture appears elsewhere in this issue. The four dozen slides shown in conjunction with this lecture by Secretary Stevers, illustrated interesting examples of the various devices and subjects under discussion. Everything electrical, from the simple electric toasters and flatirons, to the electrically propelled battleships and electrified railway systems, were covered in a general way. Immediately following the lecture, Chairman Seyferlich expressed thanks to Professor Snow, in behalf of the Local Branch and the electrical students in general, for the use of the new projecting lantern, made by the latter. The great improvements of replacing the carbon arc light by a high candle-power incandescent lamp in the new projector, eliminated the interruptions and other annoying troubles generally encountered with the former, and enabled the operator and lecturer to present the subject at hand without losing the interest of anyone present. It was emphasized that this recent improvement should act as an additional inducement for more frequent lectures in the organization in the coming year. Sample copies of the General Electric Review were then distributed and subscriptions for same were handled upon adjournment.

The following evening, Wednesday, April 21st, several local members attended a meeting of the Illuminating Engineering Society, held in the W. S. E. rooms in the Monadnock Building. Mr. M. Luckiesh, engaged in the Research Laboratory of the National Lamps Works, Cleveland, Ohio, was the speaker of the evening, and dealt with the subject, "Lighting, and the Householder." Mr. Luckiesh demonstrated that light may be used to decorate and beautify the home, and told of the splendid effects that may be secured by the proper control of color, brightness, intensity, direction and diffusion. It was also pointed out, that in spite of the fact that we can decorate with light as with no other media, there are but very few cases where light is put to such usage. With this fact in mind, Mr. Luckiesh showed how it is possible for the fixture dealer and central station operating concern to sell this idea to the householder. He also dealt with the design and sale of lighting merchandise, not as narrowly restricted to the appearance of fixtures, but rather, placed emphasis, for example, upon the superb feature of mobility, which light alone enjoys in the home, and explained how such benefit may be realized by the many, through regular merchandising channels, utilized in a different way.

Monday evening, April 26th, Mr. J. H. Lendi, Electrical Engineer of the Universal Portland Cement Co., addressed a joint meeting of the Chicago Section of the A. I. E. E. and the Electrical Section of the W. S. E., on the subject, "The Principles of Electrical Precipitation and Its Application to Cement Kiln Cases." Mr. Lendi dealt with the early history and the development of the art, together with the physical qualities of the material to be precipitated, and finally concluded with the specific plants at Duluth and Buffington. The lecture was very interesting and was illustrated by numerous lantern slides.

On Thursday, May 6th, Treasurer Smely presented an interesting discussion abstracted from the subject of his Thesis. His discussion included many important phases of Electric Transients, and was featured by the insertion of several original ideas on the subject. As many already understand, transient electric phenomena are such as occur between two permanent conditions; for example, when a load is suddenly changed, an appreciable time elapses before the generators and the line adapt themselves to the new conditions, and the currents and voltages during the intermediate time are called transients. Some electric phenomena are transient in time, as in the case of short-circuiting a large alternator; others are transient in space, for instance, the distribution of alternating current in solid conductors; and finally, some are transient both in time and space, like surges and traveling waves in long transmission lines. Since the subject was too large and advanced, to be treated in detail, Mr. Smely dealt only with the more important phases of the third case, and explained several important and interesting features of surges and traveling waves in long transmission lines. In order to simplify his discussion as much as possible, the speaker dispensed with most of the complicated mathematics, etc.

WALTER M. SEYFERLICH,
Chairman.

THE ARMOUR BRANCH OF THE WESTERN SOCIETY OF ENGINEERS.

R. M. Singer	*President*
G. C. Kumbera	*Vice-President*
G. W. Peterson	*Treasurer*
W. K. Lyon, Jr.	*Secretary*

As the semester draws to an end the Armour Branch of the Western Society of Engineers can proudly state that it has passed through a very successful period of infancy. We have a membership of 45 men, all of whom have shown an active interest in the affairs of the society. The Western Society of Engineers, the parent body, has co-operated with us in every possible way and through the kindness and courtesy of its officers we have been able to secure several prominent engineers for our talks.

On March 15th, Mr. E. E. Perkins, Consulting Engineer, gave a short talk on "Evaporation," followed by a general discussion. Mr. Perkins emphasized the fact that an engineer must have a thorough knowledge of Physics, if he expects to reach the top of his professioon. Some of us rather overlook the above fact and attempt to sleep through Prof. Wilcox's classes. It is to be remembered that some things count far more after we have left school than they seem to while we're daily customers.

Not very long ago the Electricals were boisterous over the fact that Prof. Steinmetz honored the Institute by his presence. On March 29th, Mr. T. L. Condron, chairman of the Joint Committee, gave us a fine lecture on "Reinforced Concrete in Building Construction." Although the lecture was well advertised beforehand, the attendance was not as good as was expected. The subject as presented by Mr. Condron was of interest to other students than the Civics and it is hoped that in the future when our program is of a general nature that more of the other fellows will attend.

Almost to a man we have been on inspection trips on an average of every odd Wednesday in the month. The following places have been visited within the year:

Morava Construction Co.
Packard Motor Co., Building Construction.
Michigan Ave. Bridge.
Franklin St. Bridge.
New John Crerar Library Bldg.
Armour's Northwestern Elevators.
New Drake Hotel.
American Bridge Co.
American Tinplate Co.
Portland Cement Co.
A. R. E. A. Convention and Show.

The society intends to hold a sort of farewell smoker before school closes. The date cannot be announced as yet but the social committee is working on the details. The participating members should remember that they will soon be active and that there must be more participating members to take the places that they leave vacant. Therefore get hold of the freshmen who will soon be sophomores and talk Western Society to them, bring them to the Smoker, and make them feel that they simply must get in with the regular bunch, the W. S. E. fellows.

Respectfully yours,

WILLIAM K. LYON, JR.,
Secretary.

THE CHEMICAL SOCIETY
OF
THE ARMOUR INSTITUTE OF TECHNOLOGY

E. G. Vogt	*President*
E. G. Winter	*Vice-President*
W. J. Bentley	*Secertary*
P. L. Stern	*Treasurer*

The work of the A. Ch. E. S. this year has proceeded admirably and we close the year with a feeling that the society has been an instructive factor in the curriculum. The attendance has been well above the average and the Sophomores have shown an interest in the society which we hope can be encouraged.

The society has been forunate in being able to secure excellent speakers for the meetings and we feel that each meeting has proved to be a pleasant and instructive afternoon. Some of the most interesting talks before the society were by:

Prof. H. McCormack on "The Relations Between an Employer and the Young Technical Graduate."

M. O. Eisenschimel on "The Business Side of Chemistry."

ARMOUR RADIO ASSOCIATION

H. D. Stevers ....*President*
V. L. Cooley ....*Vice-President*
A. R. Mehrhof ....*Chief Operator*
R. J. Grant ....*Secretary*

The Association has nearly completed the first round of its new existence; an active year has been passed over, replete with memories of obstacles swept away by the fire of energy and enthusiasm which animated the hearts and hands of the men. In particular, to President Stevers and Chief Operator Mehrhof is due great credit for their efficient and untiring efforts in the erection and installation of Armour's Radio outfit.

Both long and short-wave receiving sets are now in complete operation, with a receiving radius of over three thousand miles. One section of the transmitting set is also ready for business; this is the spark transmitter of one Kilowatt imput and daylight range of about two-hundred miles.

Since the erection of the station, weather conditions have been extremely unfavorable to Radio work. However, some very good receiving work has been accomplished: the stations at Honolulu, Key West, Arlington and Mexico City came in distinctly, but as yet no trans-oceanic stations have been heard.

It has been deemed advisable, in view of present government restrictions on amateur stations, and for purposes of scientific research, to obtain from the Radio Officer of the district, a special license, granting further privileges in the ether and enabling the Association to work in a broader field on a much more efficient basis.

So much progress has been made. It remains to the members active in the Association next fall to carry on this work to perfection. The hardest work has been performed for them: their duty is to accomplish results in the operation of the outfit.

THE ARMOUR ARCHITECTURAL SOCIETY

As the year of 1919-20 is drawing to a close, the A. A. S. looks back upon its record and feels that it pays to work after all, and that the fruits of these labors may also savor of pleasure.

From the calling of the first meeting in September, when the ball was started rolling, the boys have been on their toes, with the result that the A. A. S. has witnessed as progressive a year as it ever had within its prior existence.

The event of the season ended somewhat is a grand climax in the form of the annual Mardi Gras held at the Art Institute which was unanimously decided to be a fit crowning event for the year 1919-20. However, because of the number of the boys who are graduating, it was decided that the last event of the year will take place at the Art Institute, and will consist of a smoker and farewell party for the boys who will soon leave the Alma Mater. It is not necessary to say that the boys will be primed for the evening.

W. J. O'Connor.

THE ALUMNUS

Being that part of **The Armour Engineer** devoted to personal mention of the Graduates of the Aromur Institute of Technology and to the affairs of the Armour Alumni Association.

Communications should be addressed to John J. Schommer, 33rd and Federal Streets, Chicago, Ill.

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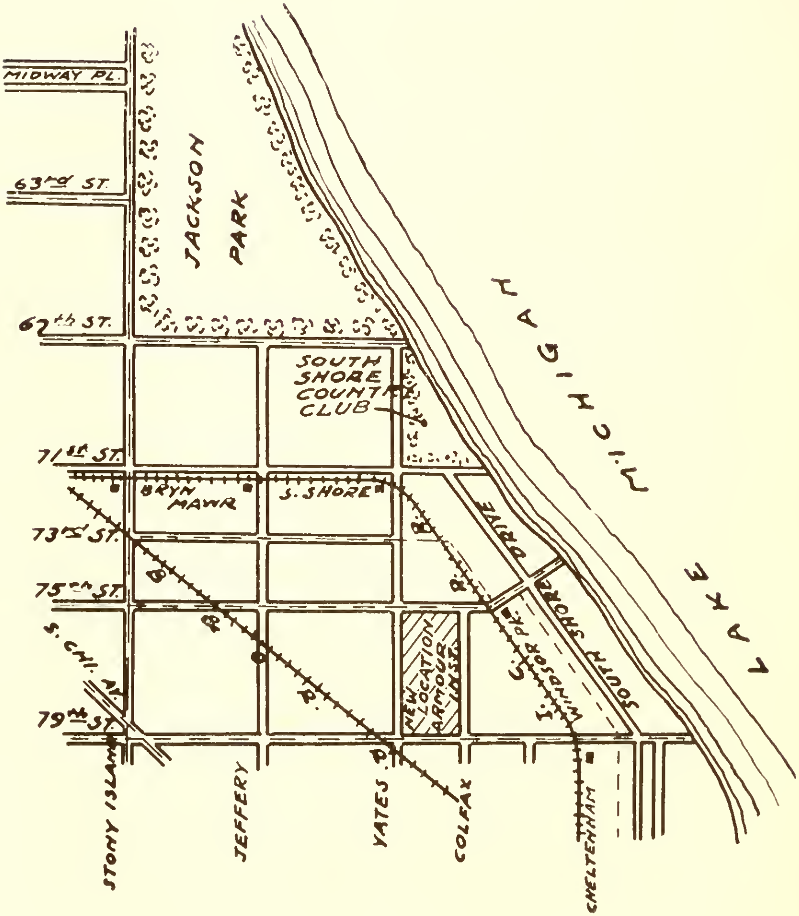
The Annual Spring Banquet of the Alumni Association has been announced for the evening of Saturday, May 22nd, at the City Club, Plymouth Court, between Jackson Blvd. and Van Buren Street.

As is the custom, the graduating class is invited to attend and to catch the spirit of enthusiasm in the alumni affairs.



New Location of Armour Institute.

COLLEGE NOTES

There are many prospects for great athletic achievements at the Institute. We are destined for an enviable place in the world of sports, and the material at hand for competent actors in each of the major activities, indicates that we are quite thoroughly prepared to meet even the most formidable teams. Our retirement from active participation in intercollegiate sports in no wise dampened the interest of the general student body in basketball, baseball and track work. The institute is steadily approaching the point where the three major sports, viz., basketball, baseball and track, will soon occupy their former places on the school's curriculum.

When the season of 1920-21 opens up, the institute will get right down to business with a view to establishing a staff of athletic teams for participation in every line of activity. It is anticipated that great numbers of students will turn out for berths on the various teams. Our good work in basketball this year, after a long lay-off, is evidence of a far more succesful season in that sport next fall. Although the basketball enthusiasts of the institute will recognize a couple of breaches in the Tech line-up, in that "Bill" Erickson and Ira Bready are to graduate this year, we are confident that a strong combination can be put into shape for competitive service with the basketball team. Perhaps the successors of these two valiant players will give to the institute the same loyal support that marked "Bill" and Ira as men of tact and prowess.

At this writing, baseball playing is the paramount athletic feature of the institute. A large squad of candidates are in the process of preparation for the Tech team. Generally speaking, these men are promising material for a strong baseball aggregation. The diamond is being rolled into condition, while the outfield experiences the touch of the gardener's rake. Our schedule in baseball is a big task for the school team, as the inclement weather and other conditions made it impossible for our squad to practice outdoors. The schedule as formulated for this season may be stated as follows:

Concordia College	April 13	At Armour
Hillsdale College	April 16	At Armour
Lake Forest College	April 17	At Armour
Valparaiso University	April 19	At Valparaiso
Augustano College	April 24	At Armour
Vaplaraiso University	April 27	At Armour
Lake Forest College	April 30	At Lake Forest
Michigan Aggies	May 3	At Lansing
Hillsdale College	May 4	At Hillsdale
Michigan Aggies	May 6	At Armour
Knox College	May 8	At Galesburg
Knox College	May 15	At Armour
Concordia College	May 17	At River Forest
Augustana College	May 19	At Rock Island

An engineering student needs to devote almost all of his time to his studies. Opportunties for active association with the athletic teams of the College are very few. There is no room in an engineerig curriculum for much recreation. The brain is trained to solve the most difficult problems that confront the American engineering world, while the muscles of the student who owns the brain are pitiably neglected. The student is too often encouraged to guard well his scholastic record, without even a passing suggestion respecting the care of his body. It is a well known fact that 40 per cent of the all-student-non-athletic-like individuals do not measure up to the standard of efficiency required of them in business. Brain has been the only medium to success in engineering or any other profession may be found in the gymnasium, on the athletic field, where one's physical structure is made more complete for important work among strong men of affairs.

A violin bow needs to be rosined in order that a melody may be rendered with total harmony; its strings are drawn to a consistent pitch so that the instrument will produce the best musical effect. The illustration just cited is closely analygous to the human body, in that the brain "cannot produce the best machanical, electrical or architectural effect," without first tuning the muscles.

Athletics are a necessity to a scholar "in the making" as any of his most difficult studies. He should participate in basketball to loosen up the nerves that have been taxed through a long day's study in the classes; he ought to play baseball to forget the difficulties confronted in Calculus or Trig., and breathe the clean, fresh air that prevades the diamond.

The athlete is a master of men. He is not only brainy but also brawny. Nothing that the world can offer is too large for him. He is the modern Atlas; powerful and progressive in every respect.

C. B. GOODMAN,
Director of Athletics.

TAU BETA PI.

Tau Beta Pi is an honorary fraternity, organized at the Lehigh University in 1885. A chapter known as Illinois Beta was started at the Armour Institute in 1906. The membership in this fraternity is limited to students in technical schools, and only those whose scholarship standing places them in the first quarter of their class are eligible to election. The "Bent" is the emblem of the organization.

The man with the highest scholarship standing in the sophomore class is eligible at the beginning of the second semester of his junior year. He is known as the Junior Honor Man. Part of the highest quarter of the Junior Class is eligible at the beginning of the second semester of the junior year. The remainder of the one-fourth are eligible at the beginning of their senior year. Eiligibility does not mean election, however. The members of the active chapter choose from the number of those eligilbe the men they desire as fraternity brothers(following to some extent the procedure of election common to all fraternities.

The Armour Chapter has two nicely furnished rooms in Chapin Hall and holds regular meetings, often of a social nature

John C. Penn.

Information as to the present address of Elmer Eric Shelberg, who attended the Institute as a Sophomore in the Architectural Course in 1913-14, has been requested. Any information will be appreciated if sent to the Editor, Armour Engineer.

ALPHABETICAL INDEX OF ADVERTISERS.

Page
Armour Institute of Technology 1
Armour & Co. 10
Banning & Banning 7
Brady Foundry Co. 5
Chas. H. Besley & Co. 4
Clarke-McElroy Publishing Co. 12
Engineering Agency, Inc., The 3
Estes Incorporated, L. V. 4
General Electric Co. 2
Hansell-Elcock Co. 9
Hills, Chas. W. 9
Jointless Fire Brick Co. 8
Koehne Studio 11
Leschen & Sons Rope Co. 7
Lufkin Rule Co. 4
Magie Bros. 9
Roebling & Sons Co., John A. 6
Swenson Evaporator Co. 7